KIPS

ENTRY TEST SERIES

For All Kinds of Entry & Aptitude Tests

PHYSICS

[redacted]

Syllabus

KIPS

ENTRY TEST SERIES

PHYSICS

(FOR ALL KINDS OF APTITUDE TESTS)

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- This diagnostic test is designed to help you to pinpoint the weak areas in your background. Sit aside 1 hour to take this test. Check your answers with those at the end of the test. Then evaluate yourself.

MCAT/ECAT

Note:- Physics paper of ECAT contains 30 questions while MCAT contains 60 questions, so extra questions have been added in the sample paper.

(1) An observer standing on a railway platform. Observes frequency of a whistling train to be 2.2kHznad 1.8 kHz of the approaching and the receding train. What is the speed of train
(a) 30ms^{-1}
(b) 20ms^{-1}
(c)10ms^{-1}
(d) 60ms^{-1}

(2) A capacitor has he capacitance of 0.0000000006 F, it can be written as
(a) 6nF
(b) 6 pF
(c) 60μF
(d) 600 pF

(3) The velocity vector of a certain uniform circular motion is given by $v = ai + bj$ .The acceleration vector will be
(a) $ai - bj$
(b)$aj + bi$
(c) $ai + bj$
(d)$aj - bi$

(4) Three forces of each magnitude 1N act from one corner towards the other three corners of a square. Their sum has the magnitude nearest to
(a) 3N
(b) 1N
(c) 5.5N
(d) 2.4N

(5) A man lifts a body to a height of 1m in 30s. An other man lifts the same mass to same height in 60s. The work done by them is in the ratio
(a) 1:2
(b) 1:1
(c) 2:1
(d) 4:1

(6) For a particle moving in uniform circular path
(a) both velocity and acceleration are transverse
(b) both velocity and acceleration are radial
(c) velocity is transverse and acceleration is radial
(d) velocity is radial and acceleration is transverse

(7) A source of sound frequency 600Hzis placed inside the water. The speed of sound in water is 1500ms^{-1} and in air it is 300ms^{-1}.The frequency of sound recorded by an observer who is standing on air is
(a) 3000Hz
(b) 900Hz
(c) 600Hz
(d) 510Hz

(8) As an electron moves through magnetic field the magnitude of force on electron
(a) decreased
(b) increased
(c) remains same
(d) can't predicted

(9) Hoc are the electrons produced in a cathode ray tube
(a) by applying an electric field to the x plates
(b)by heating a metal filament
(c) by ionization of the air
(d) by radioactive decay

(10) The time of a flight of projectile is 4sec. After 1 sec it moves an angle of 45^0. its angle of projection is
(a) $\tan^{-}(2)$ (b) $\tan^{-1}(4)$
(c) $\tan^{-1}(1)$ (d) $\tan^{-}(2/3)$

(11) A stone A is dropped from the top of tower of height of 40m. At the same time another stone B is projected from the bottom of the tower with an initial velocity such that the stones collide midway. The initial speed of second stone B is
(a) $5ms^{-1}$ (b) $20ms^{-1}$
(c) $15ms^{-1}$ (d) $10ms^{-1}$

(12) A particle is moving along a circular path with constant speed. The acceleration of the particle is
(a) 0 (b) along the tangent
(c) along radius (d) along circumference

(13) The value of e/m for positive rays is
(a) > e/m of cathode rays (b) < e/m for cathode rays
(c) equal to e/m of cathode rays (d) none of above

(14) The equation represent actinium decaying to thorium
$_{89}Ac^{227} \rightarrow _{90}Th^{227} + Y$, Which particles does Y represent
(a) alpha (b) beta
(c) gamma (d) neutron

(15) All of the following are unit of energy except
(a) erg (b) kilo watt
(c) joule (d) kilowatt hour

(16) One of the rectangular components of a force is 10N making an angle of 60 with force. The magnitude of force is
(a) 17.1 N (b) 14.1N
(c) 17.3N (d) 20N

(17) The height at which the acceleration due to gravity becomes g/9 (where g = the acceleration due to gravity on the surface of the earth) in terms of *R*, the radius of the earth, is
(a) *R/2* (b) $\frac{R}{\sqrt{2}}$
(c) $\sqrt{2}R$ (d) (d) 2R

(18) When an A.C source is connected across a resister
(a) current leads the voltage in phase
(b) current lags behind voltage in phase
(c)current and voltage are in same phase
(d) any one of above may be true depending upon resistance

(19) Which of the following does not effect the motion of moving electron
(a) electric field applied in direction of motion
(b) Mag. Field applied indirection of motion

(c) electric field perpendicular to direction of motion
(d) mag field perpendicular to direction of motion

(20) If the radius of earth decreases by 1% with density remaining same, the g on the surface
(a) decreases by 1%
(b) increases by 1%
(c) decreases by 2%
(d)increases by 1.5%

(21) An electron is injected into a uniform magnetic field with components of velocity parallel to and normal to the field direction. The path of the electron is a
(a) helix
(b) circle
(c) parabola
(d) straight line

(22) Doppler shift in frequency does not depend upon
(a) actual frequency of the wave
(b) distance of source from listener
(c) velocity of sound
(d) velocity of observer

(23) Velocity of sound is greater in solids than in gases because
(a) density of solids is high and elasticity is low
(b) both density and elasticity are low
(c) density is low and elasticity is high
(d) elasticity of solids is very high

(24) The dimensions of which of the following are same as that of impulse
(a) momentum
(b) velocity
(c) force/time
(d) none

(25) The distances traveled by body falling from lest in the 1st, 2nd & 3rd seconds are in the ratio
(a) 1:2:3
(b) 1:3:5
(c) 1:2:9
(d) none

(26) A ball covers a distance of 5m when projected with a speed of 10m/s. What are the two possible angles of projection ($g = 10m/s^2$)
(a) 45°, 45°
(b) 30°, 60°
(c) 15°, 75°
(d) 10°, 30°

(27) Two bodies having K.E in ratio 4:1 and masses in ratio 1:4 have linear momentum in ratio
(a) 1:1
(b) 1:2
(c) 2:1
(d) 1:4

(28) How much the momentum of a body would increase by increasing the K.E by 300%
(a) 50%
(b) 75%
(c) 100%
(d) 150%

(29) Two satellites are moving is the same circular orbit around the earth. They must have the same
(a) mass
(b) angular momentum
(c) K.E
(d) speed

(30) If the following properties of a wave the one that is independent of others is
(a) amplitude
(b) velocity
(c) frequency
(d) wavelength

(31) The temp at which a ferromagnetic material becomes a paramagnetic material is called
(a) critical temperature
(b) inversion temp
(c) curie temp
(d) neutral temp

(32) Which of the following is not made of soft iron?
(a) electromagnet
(b) core of dynamo
(c) core of transformer
(d) magnet of loud speaker

(33) If current in a electric bulb drops by 1%, the power decreases by
(a) 1%
(b) 2%
(c) 4%
(d) 0.5%

(34) Total energy of a particle performing S.H.M is directly proportional to
(a) Amplitude
(b) Square root of amplitude
(c) square of amplitude
(d) Reciprocal of amplitude

(35) If R/C_p for a gas of gas is 2/7 the gas could be
(a) polyatomic
(b) hetroatomic
(c) diatomic
(d) monoatomic

(36) $_{92}U^{238}$ decays through a series of transformation to a final stable nuclide. The particles emitted in the successive transformations are

$\alpha\ \beta\ \beta\ \alpha\ \alpha$

Which nuclide is not produced during the series
(a) $_{91}Pa^{234}$
(b) $_{88}Ra^{226}$
(c) $_{90}Th^{130}$
(d) $_{92}U^{234}$

(37) A young's double slit set up for interference is shifted from water to air than fringe width
(a) fringe width increased
(b) fringe width decreases
(c) fringe width remain same
(d) fringe pattern disappears

(38) Two masses of 1 kg and 4kg are moving with equal K.E. The ratio of their momentum are.
(a) 1:4
(b) 4:1
(c) 1:2
(d) 2:1

(39) In a purely capacitive circuit the current.
(a) leads the emf by π/2
(b) lags the emf by π/2
(c)are in phase
(d) both (a & c)

(40) From the top of a tower of height h a particle was thrown horizontally with velocity $(2gh)^{1/2}$. It strikes the ground at a distance from the foot of the tower equal to
(a) h
(b) h/2
(c) 2h
(d) 3h/2

(41) If A = 2i + 3i-6k and B = 4i + 6j-12k. Angle b/w A & B is
(a) 45°
(b) 60°
(c) 0°
(d) 90°

(4) The angle of projection for which the max height and horizontal range are equal is
(a) 35^0
(b) $\tan^{-1}(1/4)$
(c) 60^0
(d) $\tan^{-1}(4)$

---

(43) The tran
ultraviol
(a) 5 →
(c) 4 →

(44) A radioi
that wou
(a) 1/8
(c) 5/8

(45) What is
(a) 1.51
(c) 4.78

(46) Which c
(a) x-ray
(c) radio

(47) Two bal
is thrown
(a) ball A
(c) both

(48) A partic
the angle
(a) 0
(c) π/2

(49) E,M,L a
respectiv
(a) time
(c)mass

(50) In interf
(a) creat
(b) destr
(c) conse
(d) not c

(51) Two res
connecte
two resi
(a) 3:1
(c) 1:3

(52) A sens
magnet
(a) meta
(c) woo

(53) After 2
The act
sample
(a) 600
(c) 300

(43) The transition from the state $n = 4$ to $n = 3$ in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition from

(a) $5 \rightarrow 4$ (b) $3 \rightarrow 2$
(c) $4 \rightarrow 2$ (d) $2 \rightarrow 1$

(44) A radioisotope has a half-life of 5 years. The fraction of atoms of this material that would decay in 15 years will be

(a) 1/8 (b) 3/8
(c) 5/8 (d) 7/8

(45) What is the charge on an α-particle?

(a) $1.51\text{x}19^{-19}$C (b) $3.18\text{x}10^{-19}$C
(c) $4.78\text{x}10^{-19}$C (d) zero

(46) Which of the following waves have longest wavelength

(a) x-rays (b) infrared
(c) radio waves (d) visible light

(47) Two balls A and B are thrown from a running train ball A is just dropped while B is thrown horizontal outwards. Which of the two will reach the ground earlier.

(a) ball A (b) ball B
(c) both at same time (d) data is inadequate

(48) A particle executing one-dimensional motion finally comes to rest what will be the angle between acceleration and displacement during motion.

(a) 0 (b) π
(c) π/2 (d) π/4

(49) E,M,L and G denote energy, mass, angular momentum and gravitation constant respectively. The dimensions of EL^2/M^5G^2

(a) time (b) length
(c)mass (d) angle

(50) In interference pattern, energy is

(a) created at the position of maximum
(b) destroyed at the position of minimum
(c) conserved but is redistributed
(d) not conserved

(51) Two resistors In parallel have their resistances in the ration 1:3. A source is connected to the combination. The ratio of heats produced in a given time in the two resistors is

(a) 3:1 (b) 9:1
(c) 1:3 (d) 1:9

(52) A sensitive magnetic instrument can be effectively shielded from outside magnetic field by placing it inside a box of

(a) metal of high conductivity (b) plastic
(c) wood (d) soft iron

(53) After 280days the activity of radioactive sample is 6000cps(count per second) The activity reduces to 3000cps after another 140 days. The initial activity of the sample in cps is

(a) 6000 (b) 9000
(c) 3000 (d) 24000

(54) Two point P and Q are maintained at the potentials of 10 V and –4 V respectively. The work done in moving 100 electrons from P to Q is

(a) 9.60×10^{-17} J
(b) -2.24×10^{-15} J
(c) 2.24×10^{-16} J
(d) -9.60×10^{-17} J

(55) The uranium atom ${}_{92}U^{238}$ emits an α particle to become thorium which emits β particle to become protactinium. What is the atomic number of protactinium

(a) 90
(b) 91
(c) 89
(d) 92

(56) A convex lens of power 4 diopter is combined with a concave lense of power 3 adopter. The combination will behave as a

(a) Concave lense of .5m focal length
(b) Convex lense of .5m focal length
(c) Concave lense of 1m focal length
(d) Convex lense of 1m focal length

(57) A radioactive isotope has a half life of 2minutes. What can be deduced from this statement.

(a) after 1/2 minute, 1/4 of the isotope remain
(b)after 1 minute, 1/4 of the isotope remains
(c) after 4 minutes, 1/4 of the isotope remains
(d) after 4 minutes, none of isotope remains

(58) A boat is sent across a river with a velocity of 8km/h. If the resultant velocity of boat is 10 km/h, the river is flowing with a velocity of

(a) 12km/h
(b) 6km/h
(c) 10km/h
(d) 2km/h

(59) The displacement of a body is zero. The distance covered by it

(a) is zero
(b) is not zero
(c) may or may not be zero
(d) depends upon acceleration

(60) A neutron of mass m moves with velocity 'v' at an angle of 60 to the direction of magnetic field 'B'. The force experienced by the neutron is

(a) B
(b) BV cos 60
(c) BV sin 60
(d) Zero

KIPS ENTRY TEST SERIES

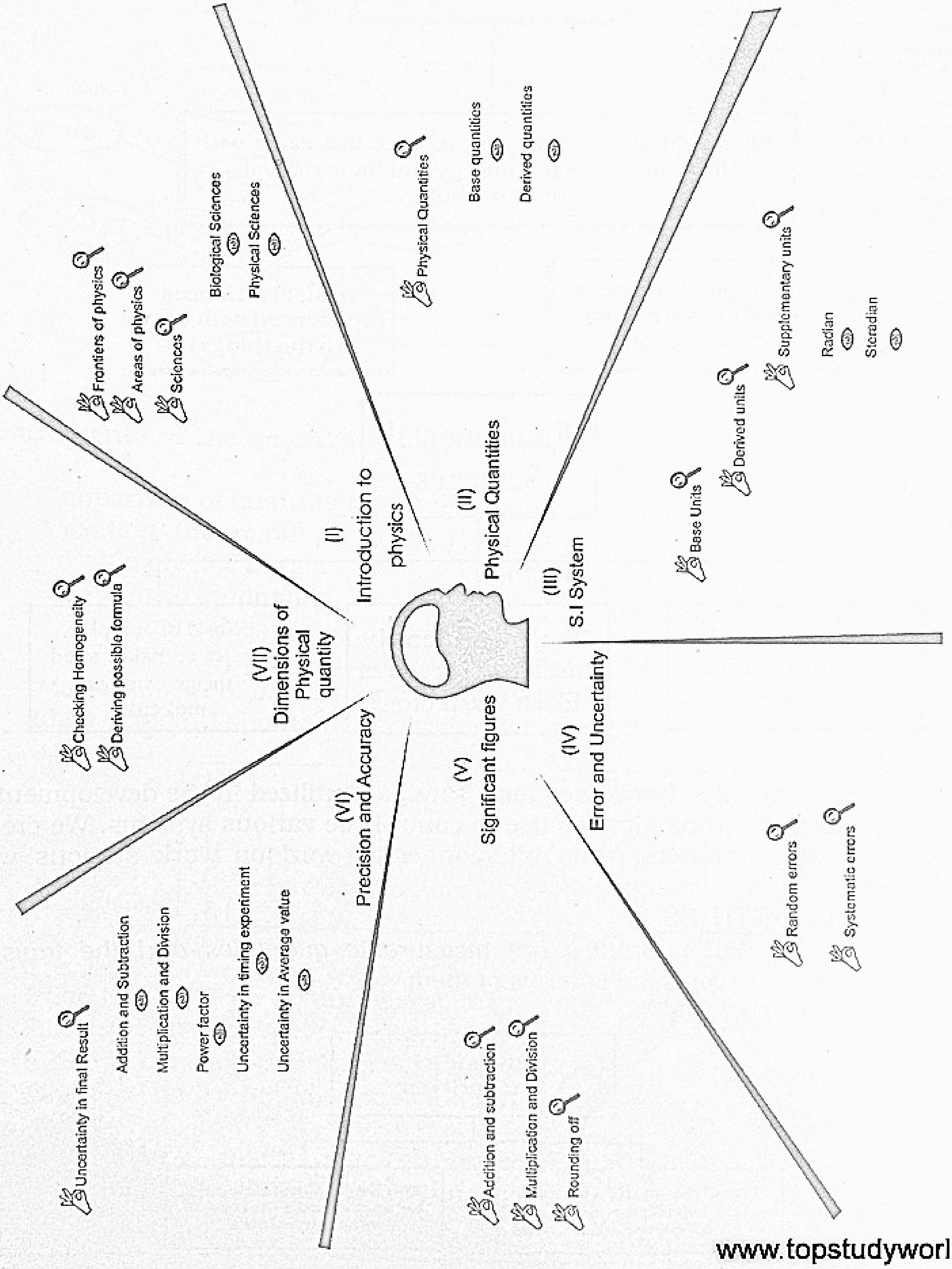
Part - I

KIPS PUBLICATION

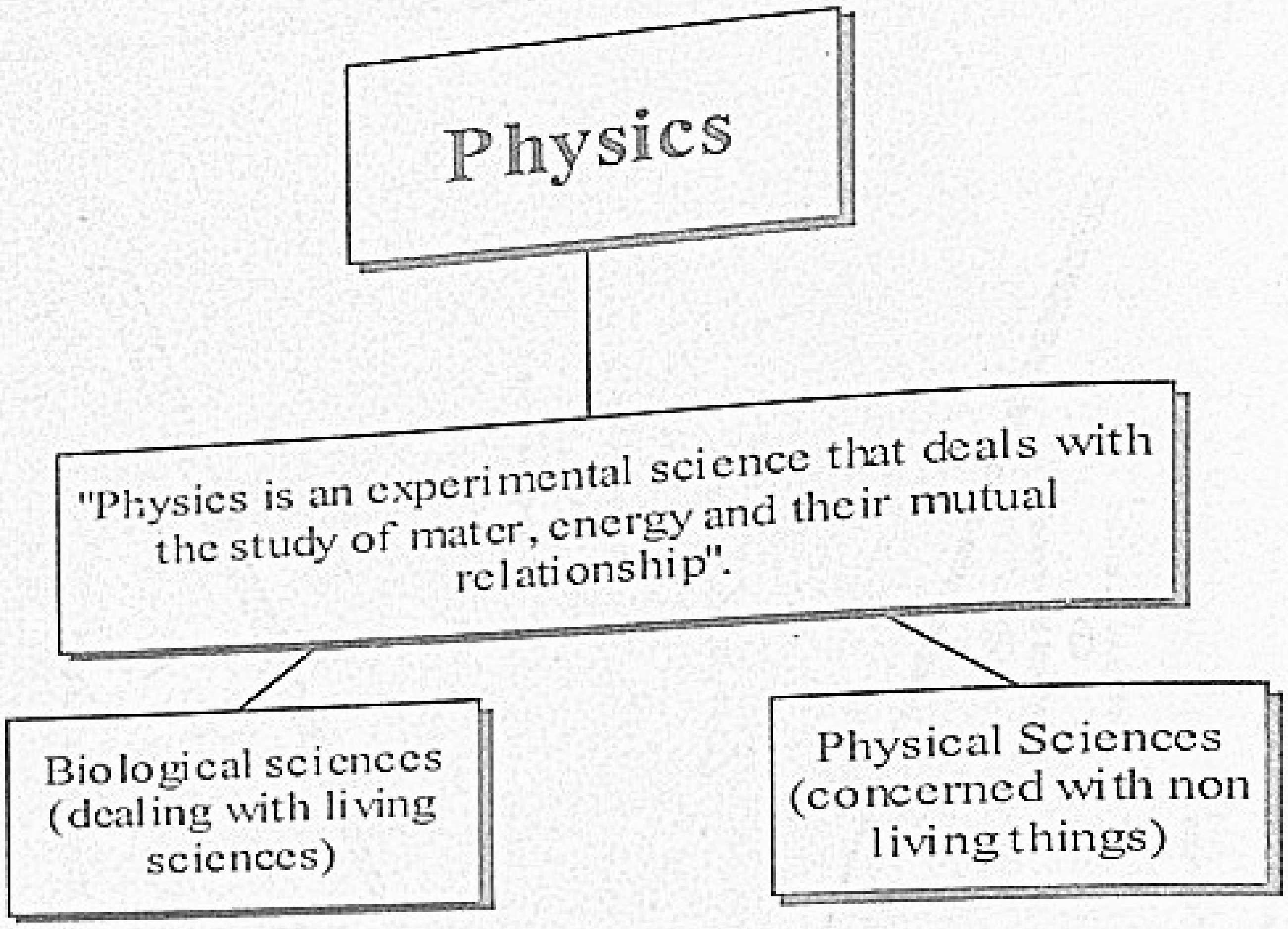
TOP Study

Chapter 1

MEASUREMENTS



INTRODUCTION

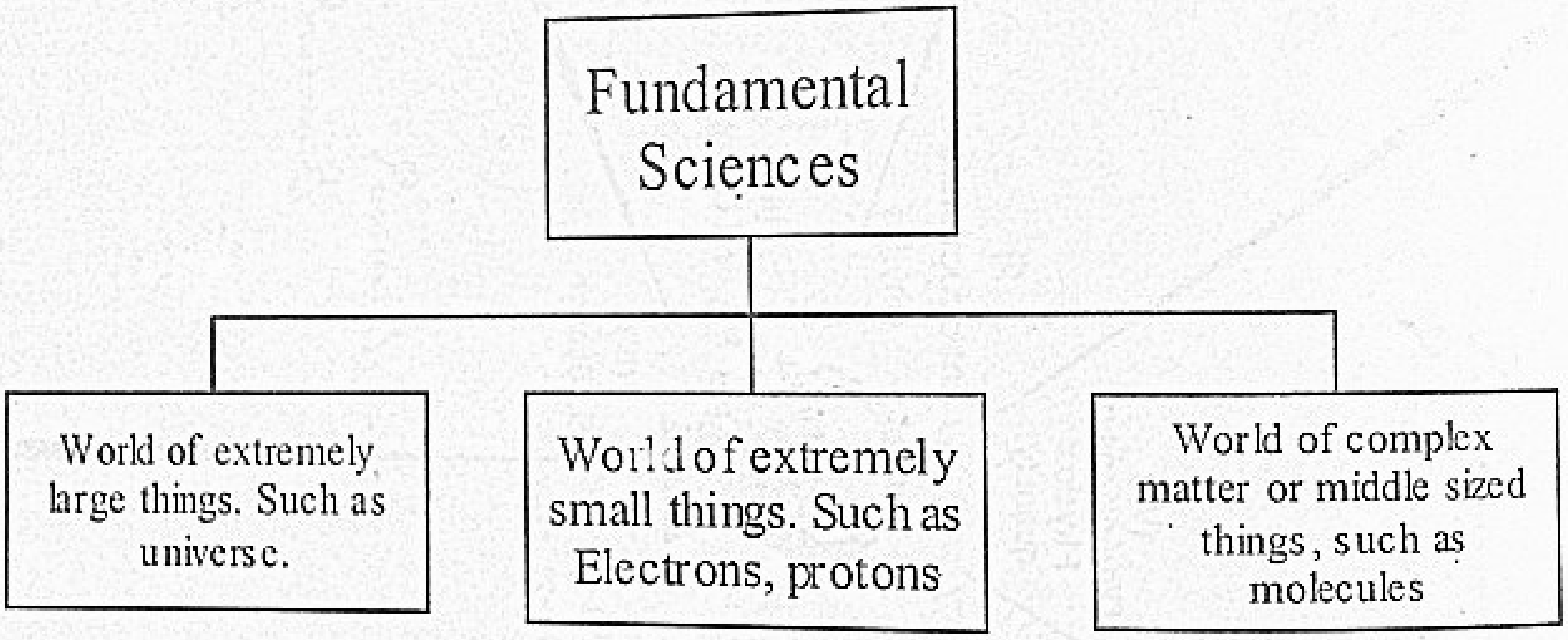


Physics

"Physics is an experimental science that deals with the study of mater, energy and their mutual relationship".

Biological sciences (dealing with living sciences)

Physical Sciences (concerned with non living things)



Fundamental Sciences

World of extremely large things. Such as universe.

World of extremely small things. Such as Electrons, protons

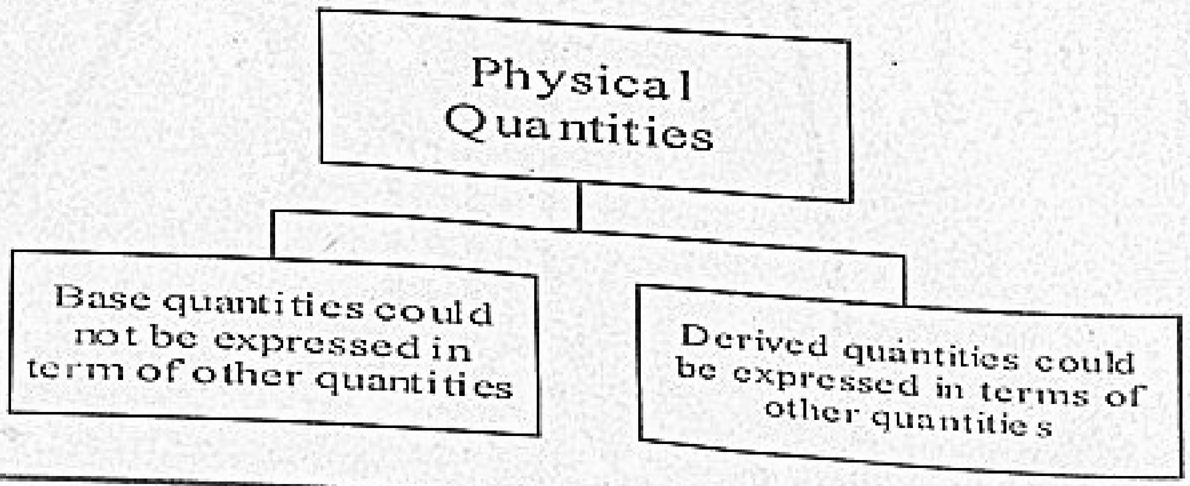
World of complex matter or middle sized things, such as molecules

The silicon chips (processed form sand) are utilized in the development of computers and electronic devices use to control the various systems. We create networks from computers, thus interconnecting various work stations with each other.

PHYSICAL QUANTITIES

Physical quantities are measurable quantities and the laws of physics are expressed in terms of them.

- ***CLASSIFICATION***

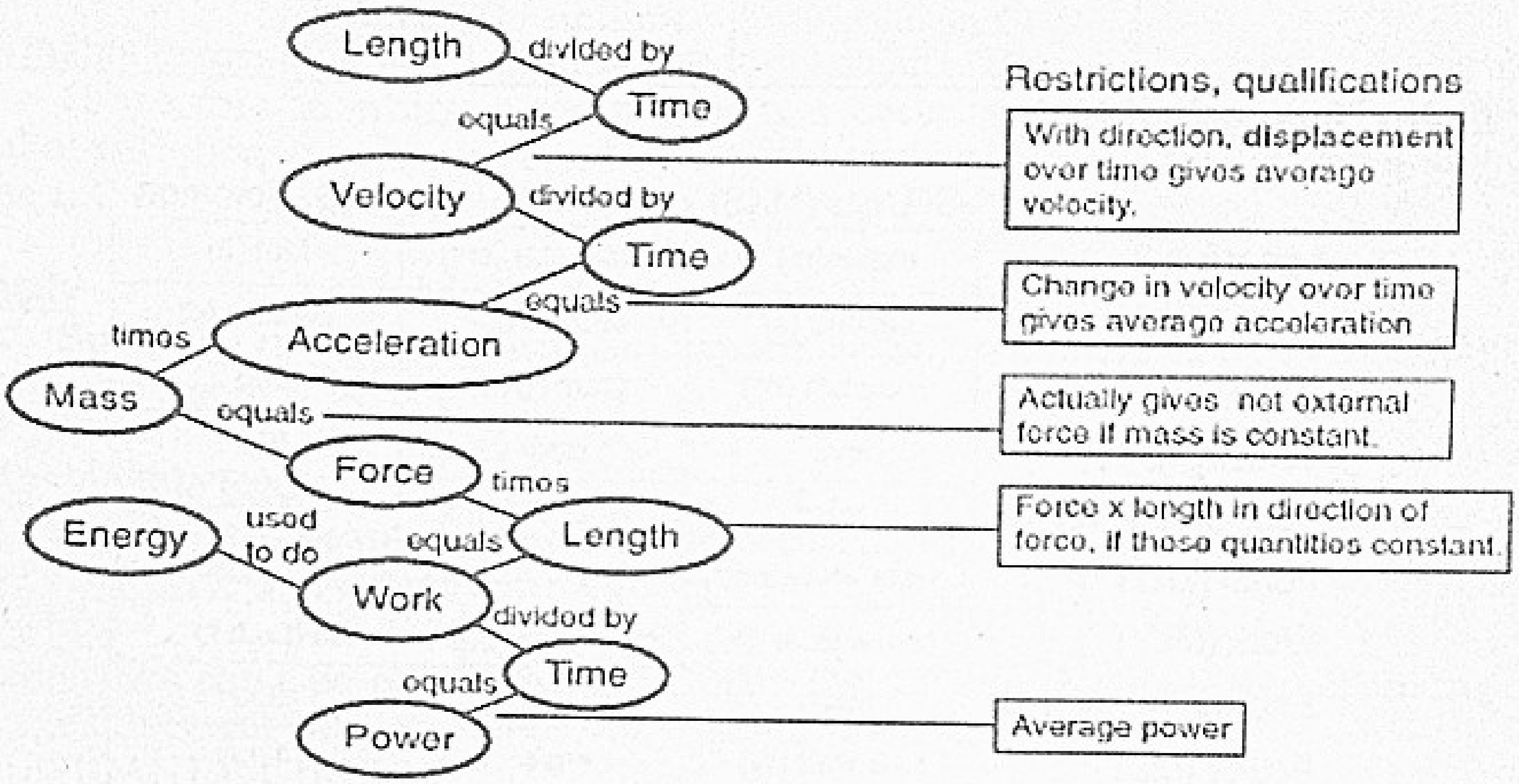


Physical Quantities

Base quantities could not be expressed in term of other quantities

Derived quantities could be expressed in terms of other quantities

Chain of Mechanical quantities


Length
divided by
Time
equals
Velocity
divided by
Time
equals
times
Acceleration
Mass
equals
Force
times
Energy
used to do
equals
Length
Work
divided by
Time
equals
Power
Restrictions, qualifications
With direction, displacement over time gives average velocity.
Change in velocity over time gives average acceleration
Actually gives net external force if mass is constant.
Force x length in direction of force, if these quantities constant.
Average power

Measurements of the quantities require the following steps.

- Comparison of quantity to be measured with a standard measuring tool.
- Encoding the result of comparison in standard format containing a suitable precise number along with appropriate unit.
    - ◊ *Basic quantities* ⇒ could not be expressed in term of other quantities
    - ◊ *Derived quantities* ⇒ based on the other physical quantities
- Measurement of basic quantities requires *the choice of standard*. Ideal standard should be accessible & invariable.

Do you know?

Ideal standard measuring tool should be fool proof via accessibility & invariability

Prior 1960, three measuring systems were in practice.

- CGS System (centimeter, gram, second)
- FPS System (foot, pound, second), or British Engineering system.
- MKS System (meter, kilogram, second)

After 1960, internationally accepted standard is SI system. In system international (SI), there are three types of units.

TOP Study

Supplementary Units

Physical Quantity	*SI Unit*	*Symbol*
Plane angle	***Radian***	***rad***
Solid angle	***Steradian***	***sr***

Basic Mechanical Units

	SI Units (MKS)	(CGS)	U.S. Common
Length (L)	meter (m)	centimeter (cm)	foot (ft)
Time (T)	second (s)	second (s)	second (s)
Mass (M)	kilogram (kg)	gram (gm)	slug
Velocity (L/T)	m/s	cm/s	ft/s
Acceleration (L/T^2)	m/s^2	cm/s^2	ft/s^2
Force (ML/T^2)	kg m/s^2=Newton(N)	gm cm/s^2= dyne	slug ft/s^2=pound(lb)
Work (ML^2/T^2)	N m = joule (j)	dyne cm = erg	lb ft = ft lb
Energy (ML^2/T^2)	joule	erg	ft lb
Power (ML^2/T^3)	j/s = watt (W)	erg/s	ft lb/s

NOTE: *Many other derived units are also used for other derived quantities.*

SCIENTIFIC NOTATION

The standard to express the number in term of power of ten is called scientific notation.

Some standard prefixes for power of ten with their symbols are presented below:-

Factor	*Prefix*	*Symbol*
10^{-18}	*atto*	*a*
10^{-15}	*femto*	*f*
10^{-12}	*pico*	*p*
10^{-9}	*nano*	*n*
10^{-6}	*micro*	*u*
10^{-3}	*milli*	*m*
10^{-2}	*centi*	*c*
10^{-1}	*deci*	*d*
10^{1}	*deca*	*da*
10^{3}	*kilo*	*k*
10^{6}	*mega*	*M*
10^{9}	*giga*	*G*
10^{12}	*tera*	*T*
10^{15}	*peta*	*P*
10^{18}	*exa*	*E*

Do you know?

There should be one non-zero digit to the left of decimal in scientific notation.

ERROR

The difference between standard and experimental values is error.

Classification of Errors

- Assignable Errors (systematic errors)
- Un assignable Errors (Random errors)

Assignable Errors

The errors to which we can assign a cause usually they follow same trend of variations so a cause can be assigned to them e.g. Errors occurring due to the L.C of the measuring instrument.

Remedy

Such errors can be controlled experimentally while carefully monitoring the measurement process.

Un Assignable Errors

To which we can't assign a cause because they do not follow a trend. So these errors are due to unknown causes.

Remedy

These errors can't be controlled experimentally, but a statistical tool of taking average of several values is employed to minimize them.

SIGNIFICANT FIGURES

Uncertainty in the measurements leads us to establish some standard to write the numerical value of a measurement, termed as significant figure.

" In any measurement, all the accurately known digits and the first doubtful digit are named as significant figures."

Do you know?

Greater the significant figures in a measurement the more accurate it is

Rules of significant figures

In order to determine significant figures in a number we must follow the following rules:

(1) All the non-zero digits are significant figures.
For Example:
3.456 has four significant figures.
12.3456 has six significant figures.
0.34 has two significant figures.

(2) Zeros between non-zero digits are significant.
For Example:
2306 has four significant figures.
20,0894 has six significant figures.

(3) Zeros locating the position of decimal in numbers of magnitude less than one are not significant.
For Example:
0.2224 has only one significant figures.
0.0000034 has two significant figures.

(4) Final zeros to the right of the decimal point are significant.

TOP Study

For Example:
3.0000 has five significant figures.
1002.00 has six significant figures.

(5) Zeros that locate decimal point in numbers greater than one are not significant.

For Example:
30000 has only one significant figure.
120000 has two significant figures.

Rules for digits to be Retained after Arithmetic calculations in Results

The No. of significant figures contained by a digit, obtained as out come of arithmetic operations multiplication or division should not be more than the least accurate digits. e.g.

$$\frac{4.54 \times 2.324}{1.3365} = 7.89447063$$

The result should contain three significant figures as the least accurate digits to be operated under these operations contain three significant figure numbers, so rest of the digits are dropped.

Rounding off Data

Rule # 1:

If the digit to be dropped is greater than 5, then add "1" to the last digit to be retained and drop all digits farther to the right.

For example:

3.677 is rounded off to 3.68 if we need three significant figures in measurement.

3.677 is rounded off to 3.7 if we need two significant figures in measurement.

Rule # 2:

If the digit to be dropped is less than 5, then simply drop it without adding any number to the last digit.

For example:

6.632 is rounded off to 6.63 if we need three significant figures in measurement.

6.632 is rounded off to 6.6 if we need two significant figures in measurement.

Rule # 3:

If the digit to be dropped is exactly 5 then:

(A) If the digit to be retained is even, then just drop the "5".

For example:

6.65 is rounded off to 6.6 if we need two significant figures in measurement.

3.4665 is rounded off to 6.466 if we need four significant figures in measurement.

(B) If the digit to be retained is odd, then add "1" to it.

For example:

6.35 is rounded off to 6.4 if we need two significant figures in measurement.

3.4675 is rounded off to 6.468 if we need four significant figures in measurement.

Remember: Zero is an even number

3.05 is rounded off to 3.0 if we need two significant figures in measurement.

PRECISION & ACCURACY

Precision

The precision of a measurement is determined by the instrument or device.

Smaller the least count of instrument, more precise is the measurement.

Accuracy

The accuracy of a measurement depends upon the fractional or percentage uncertainty in the measurement.

Smaller the percentage error, more accurate is the measurement. Absolute uncertainty is equal to the least count of the measuring instrument.

Assessment of Total Uncertainty in the Final Result

Total uncertainty in the final result can be determined by the following rules:

∘In addition and subtraction we consider the significant figures on the right side of decimal point. This means that only as many digits are to be retained to the right side of decimal point as the number with fewest digits to the right of the decimal point.

For example: $4.345 + 23.\underline{5} = 27.845$ (actual answer by using calculator)

Answer after rounding off: 27.8

∘ In multiplication and division , the number obtained after calculation of two or more numbers must have no more significant figure than that number used in multiplication or division.Forexample:$4.3458 \times 2.7 = 11.7\underline{3366}$(actual answer by using calculator)

Answer after rounding off: 12(because 2.7 has only two significant figures)

∘For power factor the power is multiplied with the percentage uncertainty.

∘For average value of many measurements, the mean deviation from the average value is the uncertainty in the average value.

∘For time measurement, uncertainty is obtained by dividing the least count of the timing device with the number of vibrations.

Do you know?
Counting more number of vibrations can reduce the uncertainty in the timing experiments.

DIMENSIONS

Each basic measurable physical quantity is represented in term of base quantities by a specific symbol for them written with in square brackets is called dimension.

- The dimensions are helpful in-
  - ◊Deriving a possible formula
  - ◊Checking the homogeneity of a physical equation or formula.

- ***Limitations of Dimensional Analysis***
- Dimension analysis has no information on dimensionless constants.
- If a quantity is dependent on trigonometric or exponential function, this method cannot be used.
- In some cases, it is difficult to guess the factors while deriving the relation connecting two or more physical quantities.
- This method cannot be used in an equation containing two or more variables with same dimensions.

PRACTICE EXERCISE

30 min Time Period

(1) Which one is not a branch of physical sciences?
(a) chemistry (b) astronomy
(c) geology (d) biology

(2) The dimension of energy density is same as that of
(a) pressure (b) force
(c) $(\text{velocity})^2$ (d) acceleration

(3) Which property of a solid object cannot be changed by the application of force
(a) length (b) mass
(c) area (d) speed

(4) For what physical quantity is the pascal a unit?
(a) stress (b) pressure
(c) Young's modulus (d) all of these

(5) In scientific notation numbers are expressed in
(a) power of ten (b) powers of two
(c) reciprocal (d) decimal

(6) 1024 can be written in scientific notation as
(a) 1.024×10^3 (b) 2^{10}
(c) 0.000976 (d) 1/0.00097

(7) Prefix deca represents
(a) 10^1 (b) 10^2
(c) 10^3 (d) 10^{-1}

(8) The error in measurement may occur due to
(a) inexperience of a person (b) the faulty apparatus
(c) inappropriate method (d) due to all reasons in a , b and c

(9) The uncertainty in a measurement may occur due to
(a) limitation of an instrument
(b) natural variation of the object to be measured
(c) inadequate of technique
(d) all given in a, b and c

(10) Random errors can be reduced by
(a) taking zero correction
(b) comparing the instrument with another more accurate one
(c) taking mean of several measurement
(d) all methods explained in a, b and c

(11) In any measurement the significant figures are
(a) all accurately known and all doubtful digits
(b) only accurately known digits
(c) only doubtful digits
(d) all accurately known digits and the first doubtful digit

(12) A digit zero in a measurement
(a) may be significant may not significant
(b) always significant
(c) always insignificant
(d) significant only if left to a significant figure

(13) Number of significant figures in 0.0173 are
(a) three
(b) four
(c) five
(d) two

(14) Smaller the least count of the instrument more is the measurement
(a) accurate
(b) precise
(c) accurate and precise
(d) none of these

(15) Which system of the units is a coherent system of units in mechanics
(a) CGS
(b) MKS
(c) FPS
(d) All of these

(16) $ML^{-1}T^{-2}$ is the dimension of
(a) force
(b) pressure
(c) momentum
(d) energy

(17) Dimensional analysis is helpful for
(a) deriving a possible formula
(b) checking the homogeneity of a physical equation
(c) verification of laws
(d) only a and b are correct

(18) Which equation is not dimensionally correct?
(a) $E=mc^2$
(b) $Vf=Vi+at$
(c) $S=Vt^2$
(d) $S=1/2at^2$

(19) SI unit of coefficient of viscosity is
(a) $Kg.m.S^{-1}$
(b) $Kg\ m^{-1}.S^{-1}$
(c) Kg.m.S
(d) $Kg^{-1}.m^{-1}.S^{-1}$

(20) Three students measured length of a needle with meter rod and recorded as: (i) 0.2145m (ii) 0.21m (iii) 0.214m. Which one is correct record?
(a) only (i)
(b) only (ii)
(c) only (iii)
(d) both (i) and (ii)

(21) One light year is equal to
(a) 9.5×10^{15}m
(b) 9.5×10^{15}sec
(c) 9.5×10^{15}Km
(d) 9.5×10^{15}cm

(22) Absolute uncertainty in a measurement depends upon
(a) magnitude of the measurement
(b) least count of the instrument
(c) percentage error in the measurement
(d) system of unit

(23) Steradian is the SI unit of
(a) plane angle
(b) solid angle
(c) both plane angle and solid angle
(d) neither plane angle nor solid angle

(24) Which pair has same dimension
(a) work, torque
(b) work, energy
(c) energy, torque
(d) all are correct

TOP Study

(25) Total uncertainty, in result obtained from the subtraction of two measurement, is equal to

(a) sum of their absolute uncertainties
(b) difference of their absolute uncertainties
(c) product of their absolute uncertainties
(d) division of their absolute uncertainties

(26) Which one is the highest power multiple?

(a) giga
(b) beta
(c) mega
(d) deca

(27) One femto stands for

(a) 10^{-15}
(b) 10^{-12}
(c) 10^{-9}
(d) 10^{-6}

(28) Percentage uncertainty in radius r is 2%. The percentage uncertainty in volume of sphere is

(a) 4%
(b) 6%
(c) 8%
(d) 9%

(29) The unit of force is ________ and its symbol is __________. Which is the correct pair?

(a) Newton, n
(b) Newton, N
(c) newton, n
(d) newton, N

(30) Which of the following length is more precise measured by the instrument having least count of 0.00001cm, (1) 5cm (2) 5.00cm (3) 5.000cm (4) 5.00000cm

(a) 1
(b) 2
(c) 3
(d) 4

(31) Which one is the derived quantity in SI units?

(a) electric current
(b) electric charge
(c) plane angle
(d) amount of substance

(32) Which one is the correct representation of the unit of pressure?

(a) Newton/Meter^2
(b) newton/meter^2
(c) Newton/meter^2
(d) newton/Meter^2

(33) Which one is the dimensionally correct equation?

(a) $f=vt$
(b) $S=Vit+1/2at^2$
(c) $V=St$
(d) $V=f/t$

(34) Zero error of the instrument is a type of

(a) random error
(b) personal error
(c) systematic error
(d) classified error

(35) In multiplication and division of measurement

(a) percentage uncertainties are added
(b) absolute uncertainties are added
(c) percentage uncertainties are divided
(d) absolute uncertainties are divided

(36) The number of significant figures in 5.400 are

(a) thee
(b) five
(c) two
(d) none

---

(37) To red
(a) us
(b) co
(c) co
(d) bo

(38) The r
measu
(a) fou
(c) two

(39) A wir
cross-
(a) 1%
(c) 4%

(40) Which
(a) 1m
(c) 10

(37) To reduce the uncertainty in the timing experiment
(a) use highly precise instrument
(b) conduct at room temperature
(c) count more number of vibration
(d) both a and c

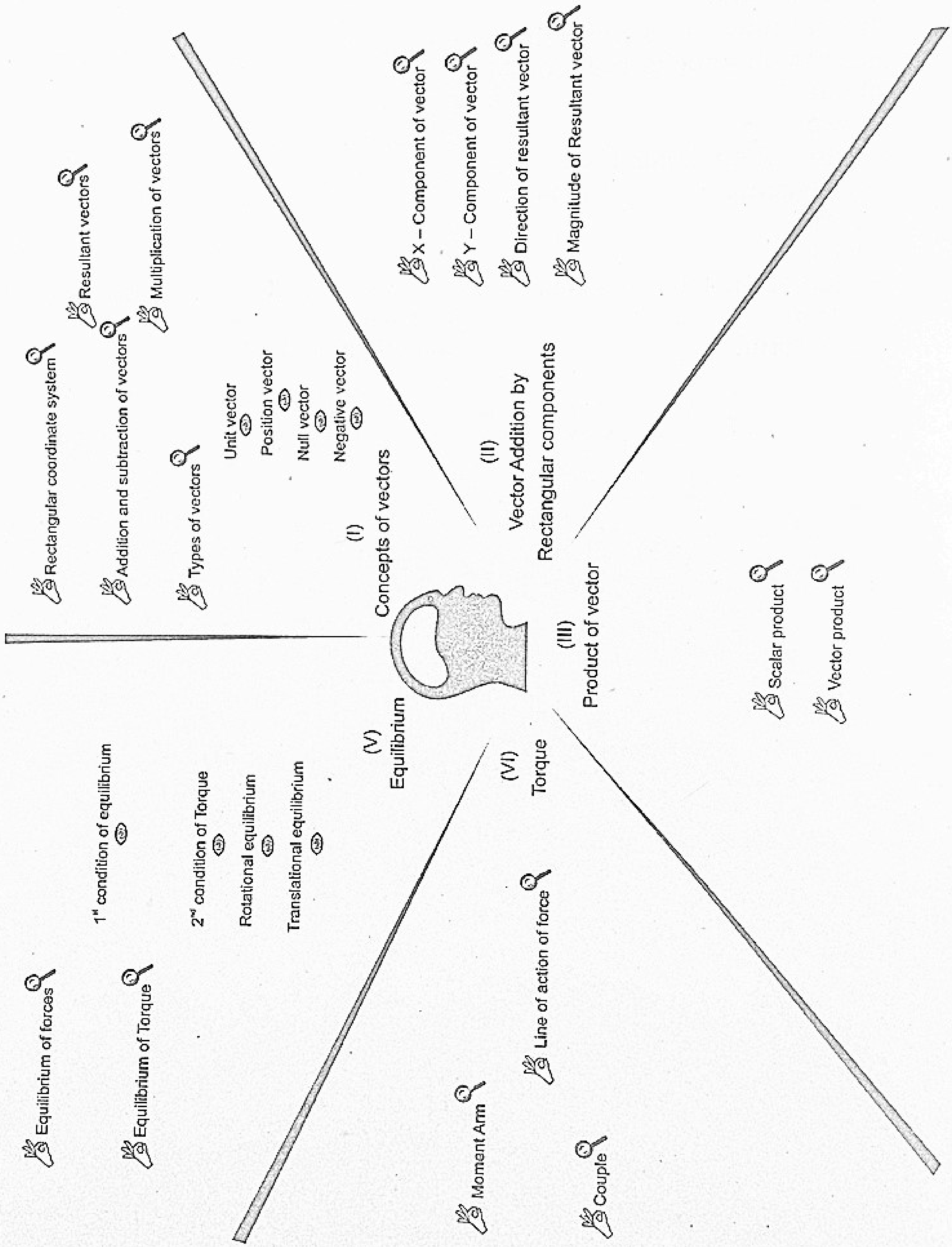
(38) The number of significant figures in the length of a bar 9800mm measured by meter rod are
(a) four
(b) three
(c) two
(d) none of these

(39) A wire when heated shows a 2% increase in length. The increase in cross-section area would be
(a) 1%
(b) 2%
(c) 4%
(d) 8%

(40) Which of the following is not a correct representation method for prefixes
(a) 1mm
(b) 10km
(c) 1000μm
(d) both (a) and (b)

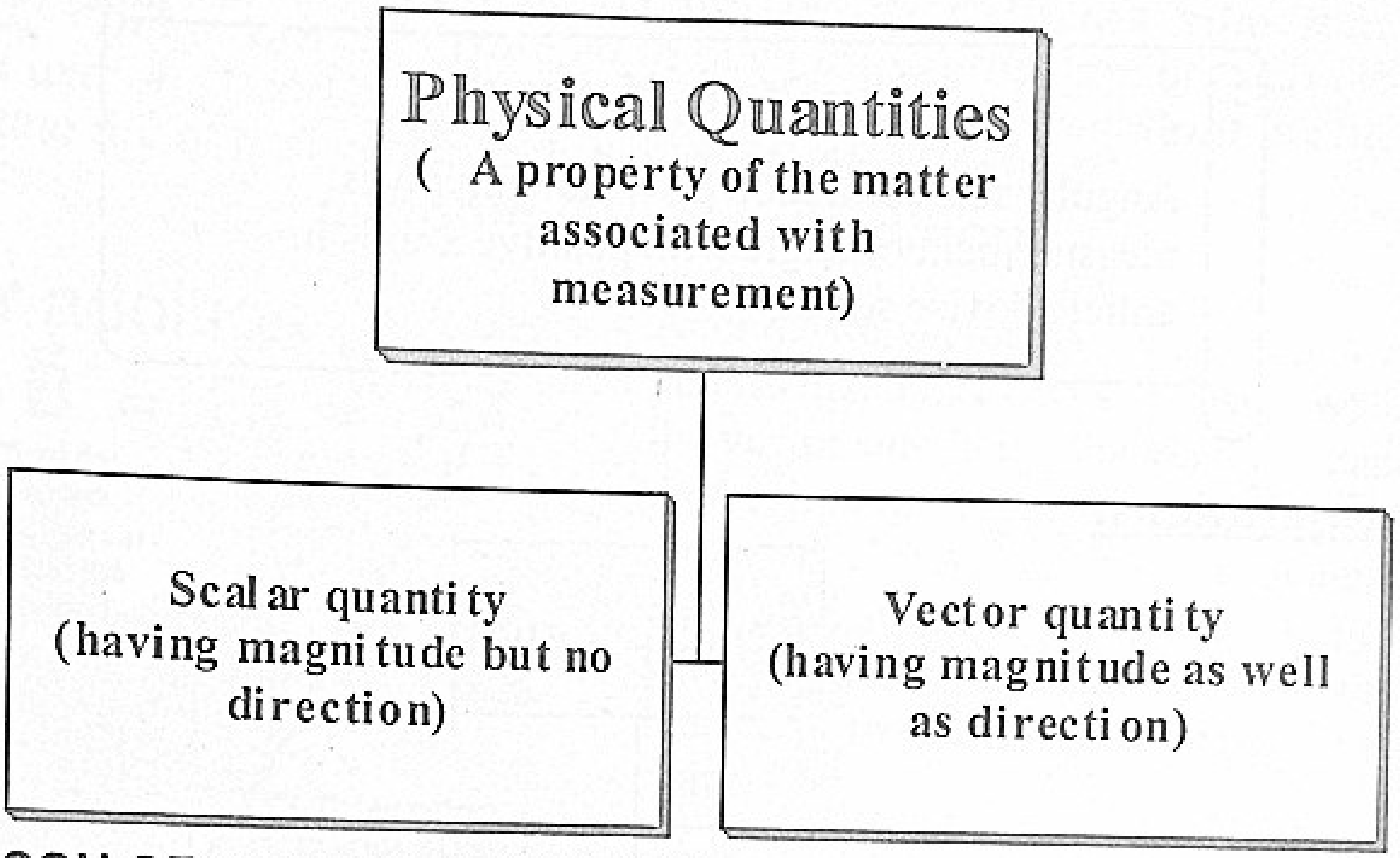
Chapter 2

VECTORS & EQUILIBRIUM



Chapter 2 Vectors & Equilibrium

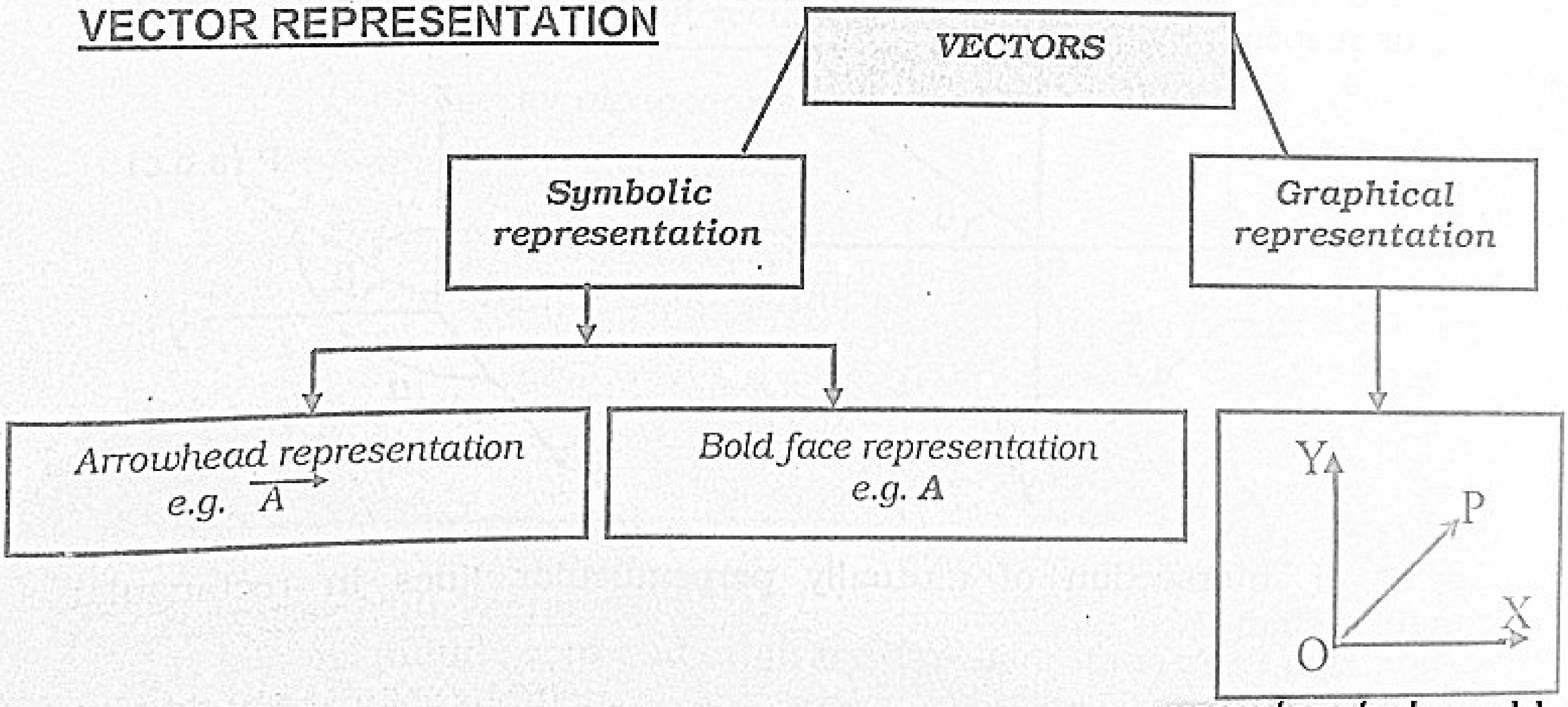
INTRODUCTION


Physical Quantities
(A property of the matter associated with measurement)
Scalar quantity
(having magnitude but no direction)
Vector quantity
(having magnitude as well as direction)

COMPARISON OF SCALAR AND VECTOR

Particulars	***Scalars***	***Vectors***
Definition.	*Non-directional physical quantity*	*Directional physical quantity*
Examples	*time, volume, work & flux*	*Displacement, velocity & torque*
Representation requirements	*Numerical value* *Proper unit*	*Numerical value* *Proper unit* *Direction*
Subtraction	*By simple arithmetic rules*	*By special rules*
Addition	*By simple arithmetic rules*	*By special rules*
Multiplication	*By simple arithmetic rules*	*By special rules*
Division	*By simple arithmetic rules*	*Not possible*

VECTOR REPRESENTATION

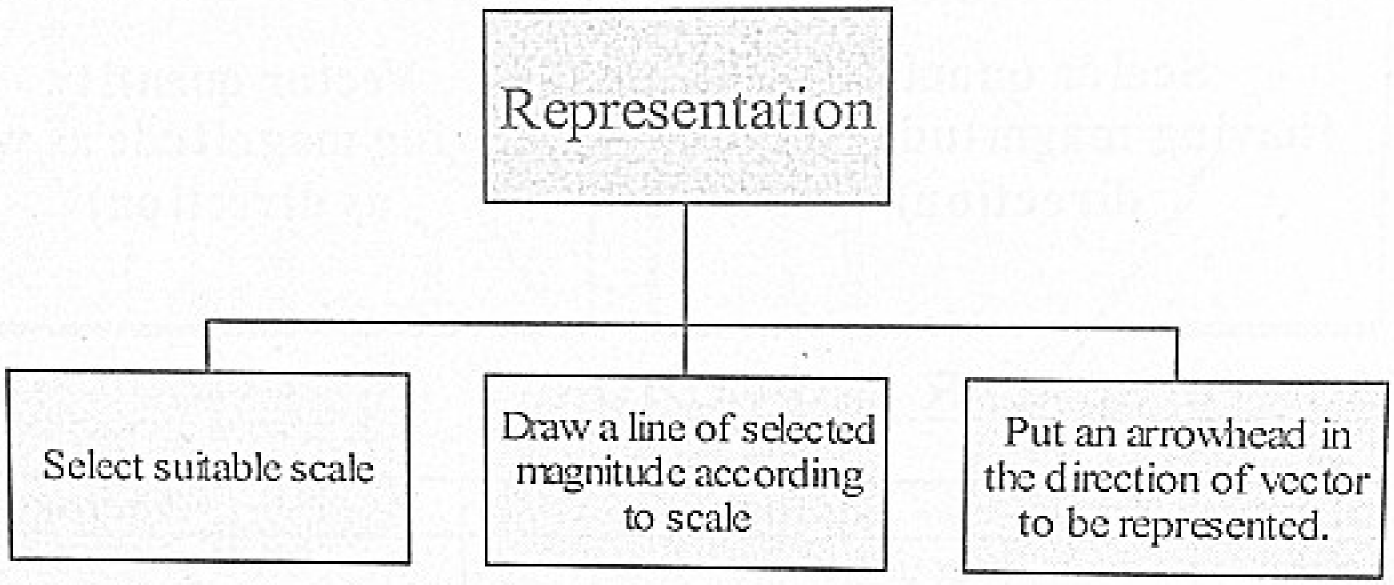


STEPS TO REPRESENT VECTORS GRAPHICALLY

Do You Know?

Angular representation of vectors involves measurement of angle with positive x-axis in anticlockwise sense.

Vector Operations:


Representation
Select suitable scale
Draw a line of selected magnitude according to scale
Put an arrowhead in the direction of vector to be represented.

Rectangular Coordinate System

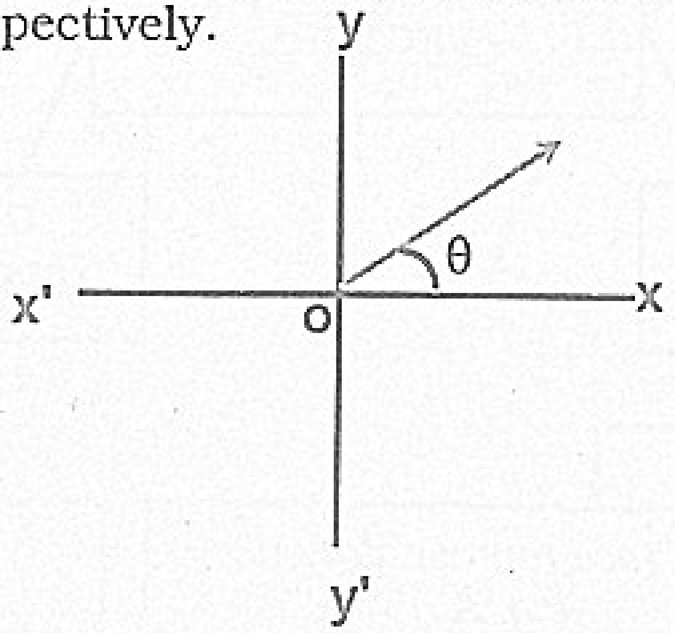
Two-dimensional

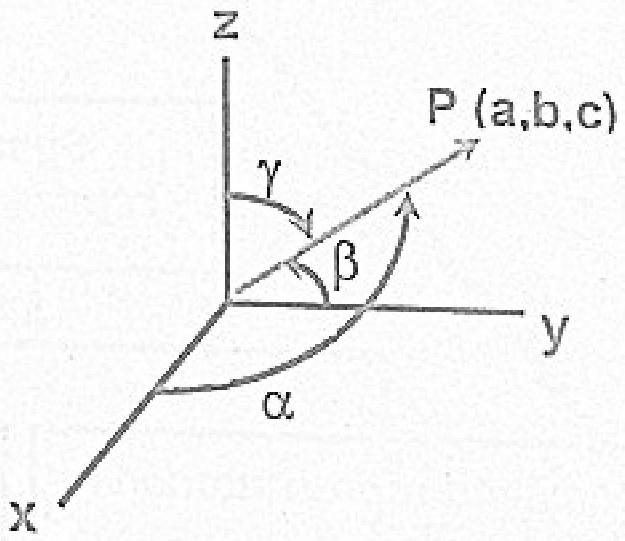
It consists of two mutually perpendicular lines, called x-axis and y-axis. One angle is used to specify the direction of a vector in two-dimensional coordinate system.

Three-dimensional

It consists of three mutually perpendicular lines called x-axis, y-axis and z-axis.

The direction of a vector in three dimensional rectangular coordinate system is specified by three angles making with x, y and z-axis respectively.





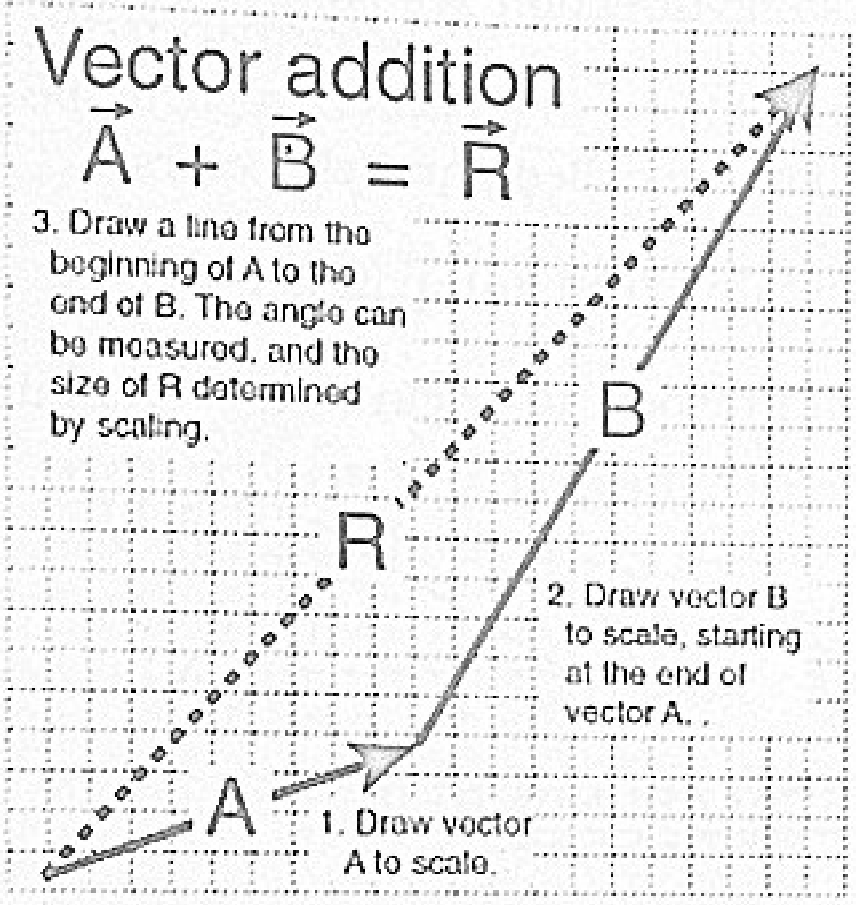
Origin

The point of intersection of mutually perpendicular lines in rectangular coordinate system.

ADDITION AND SUBTRACTION OF VECTORS

- We can add and subtract vectors by head to tail rule that states: *"If vectors are arranged in such a way that tail of each next vector join with the head of its preceding vector, then the resultant is obtained by joining tail of first vector with the head of last one."*

Graphical Vector Addition



3. Draw a line from the beginning of A to the end of B. The angle can be measured, and the size of R determined by scaling.

2. Draw vector B to scale, starting at the end of vector A.

1. Draw vector A to scale.

Adding two vectors A and B graphically can be visualized like two successive walks, with the vector sum being the vector distance from the beginning to the end point. Representing the vectors by arrows drawn to scale, the beginning of vector B is placed at the end of vector A. The vector sum R can be drawn as the vector from the beginning to the end point.

The process can be done mathematically by finding the components of A and B, combining to form the components of R, and then converting to polar form.

TYPES OF VECTORS

Resultant Vector

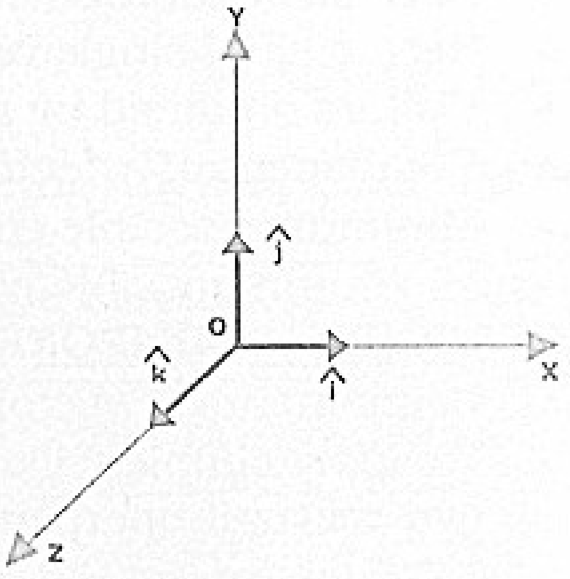
It is a single vector that has the same effect as all the vectors to be added.

Unit Vector

It has magnitude 1 and direction of it is along the given vector. It is obtained by dividing the vector with its magnitude i.e. $\hat{A} = \vec{A}/|A|$

Some commonly used unit vectors are

$\hat{i}$ - unit vector along x-axis
$\hat{j}$ - unit vector along y-axis
$\hat{k}$ - unit vector along z-axis
$\hat{r}$ - unit vector along position vector
$\hat{n}$ - unit vector along normal (perpendicular)

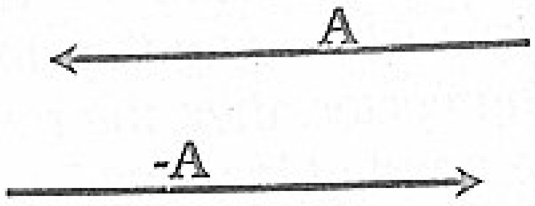


Zero Vector or Null Vector

It has magnitude zero and arbitrary direction. Its symbol is O and used as vector identity for addition.

Negative of a vector

It is a vector of same magnitude but has opposite direction e.g.



Point to Ponder

We cannot add zero to null vector.

Equal Vectors

Vectors having same magnitude and same direction are said to be equal vectors

Parallel Vectors

The vectors that have only same direction are called parallel vectors

Anti parallel Vectors

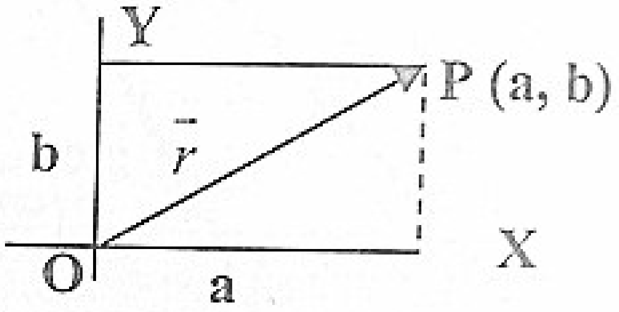
The vectors that have opposite direction are called anti parallel vectors.

Position Vector

It represents the position of a point with respect to origin in a coordinate system. Its symbol is **r**.

In two dimensions, $\vec{r} = a\hat{i} + b\hat{j}$

In three dimensions, $\vec{r} = a\hat{i} + b\hat{j} + c\hat{k}$



MULTIPLICATION OF A VECTOR WITH A SCALAR (NUMBER)

- Resultant remains a vector
- Magnitude may or may not be changed as number can be 1 or >1.
- Direction may or may not be changed, as number can be positive or negative.

e.g. if number = n & vector = **A**, then after multiplication

New vector = n**A**

Magnitude = n times the magnitude of **A** i.e. nA

Dimensions of scalar and vector are also multiplied to give the dimension of new vector.

RESOLUTION OF A VECTOR

- Reverse of addition of vectors.
- Replacing of single vector by two or more than two vectors.
- Vectors obtained by resolving a vector are called components.
- Component of a vector is its effective value in the stated direction.
- Minimum possible components of vectors are two.
- Maximum possible components of a vector are infinite.

RECTANGULAR COMPONENTS OF A VECTOR

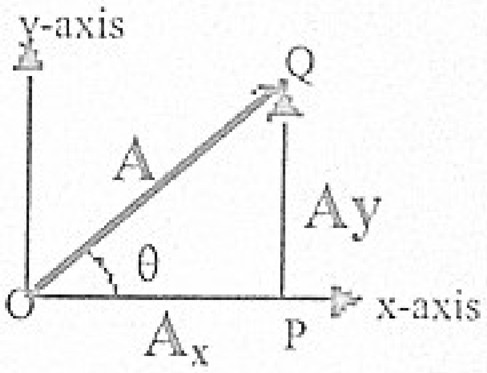
- Components of vector which are mutually perpendicular to each other.
- To apply simple trigonometric formulae we resolve vectors in a plane into two mutually perpendicular components called rectangular components e.g.

Where

$A_x = A\cos\theta$------------ (i)

$A_y = A\sin\theta$-------------(ii)

- Direction of components is governed by angle 'θ'.



DETERMINATION OF A VECTOR FROM RECTANGUALR COMPONENTS:-

Squaring and adding (i) and (ii), their simplification yields.

$$|A| = \sqrt{Ax^2 + Ay^2} \qquad (\cos^2\theta + \sin^2\theta = 1)$$

For direction dividing (i) and (ii)

$$\theta = Tan^{-1}\left(\frac{A_y}{A_x}\right)$$

ADDITION OF VECTORS BY RECTANGULAR COMPONENTS

- Let resultant of two vectors **A** and **B** be **R**. Its magnitude is given as

$$R = \sqrt{(R_x)^2 + (R_y)^2}$$

Where

$$R_x = A_x + B_x$$
$$R_y = A_y + B_y$$

- Direction of the resultant vector is determined by

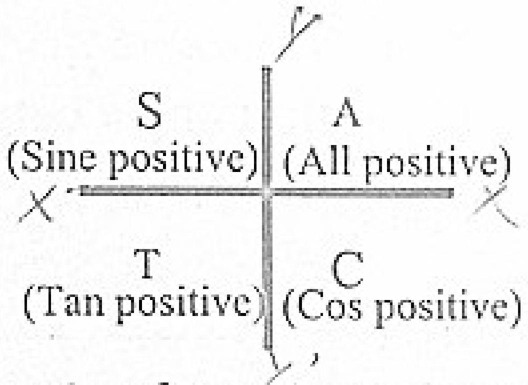
$$\theta = \tan^{-1}(R_y/R_x)$$

- For any number of vectors the magnitude of the resultant

$$R = \sqrt{(A_x+B_x+C_x+\ldots\ldots)^2+(A_y+B_y+C_y+\ldots\ldots)^2}$$

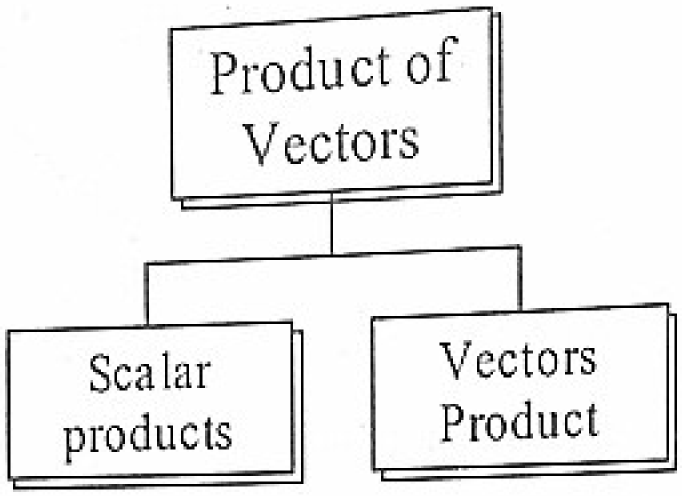
$$\theta = \tan^{-1}(A_y+B_y+C_y+\ldots../A_x+B_x+C_x+\ldots..)$$

- Remember following diagram-



Keeping in mind the conventions for measuring angle of resultant vector, you can calculate the angle using the table below: -

Situation	Quadrant	Angle calculated	Angle calculated according to conventions.
$R_x \rightarrow$ Positive $R_y \rightarrow$ Positive	1st	θ	Φ = θ
$R_x \rightarrow$ Negative $R_y \rightarrow$ Positive	2nd	θ	Φ = 180-θ
$R_x \rightarrow$ Negative $R_y \rightarrow$ Negative	3rd	θ	Φ = 180+θ
$R_x \rightarrow$ Positive $R_y \rightarrow$ Negative	4th	θ	Φ = 360-θ



Point to Ponder....
Is a Current (I) scalar quantity or Vector quantity?

SCALAR OR DOT PRODUCTS

If product of two vectors is a scalar, then is called scalar product or dot product.

$$\mathbf{A}\ .\ \mathbf{B} = AB\cos\theta.$$

Example of dot product
Work (scalar quantity) is dot product of force and displacement vector.

Characteristics of scalar product

Let us consider two vector $\vec{A}$ and $\vec{B}$ to elaborate characteristics.
Scalar product holds commutative law i.e.

$$\vec{A}.\vec{B} = \vec{B}.\vec{A}$$

- Holds association law i.e.
  $m\vec{A}.n\vec{B} = n\vec{A}.m\vec{B} = mn\vec{A}.\vec{B}$ (m and n are numbers)
- If $\vec{A}.\vec{B}$ =0 means θ=90° or $\left(\vec{A}\right)=0$ or $\left(\vec{B}\right)=0$ or both.
- For unit vector $\hat{i}, \hat{j}, \hat{k}$
  $\hat{i},.\hat{j}=\hat{j}.\hat{k}=\hat{k}.\hat{i},=0$
- To find angle between two vector to be multiplied.

$$\theta = Cos^{-1}\left(\frac{A_xB_x + A_yB_y + A_zB_z}{AB}\right)$$

Do You Know?
Scalar product of two parallel vectors is equal to the product of their magnitudes only.

- The result of product of two equal vectors is equal to the square of their magnitudes. (Self scalar product).

$$\vec{A}.\vec{A} = A^2.$$

VECTOR OR CROSS PRODUCT

If product of two vectors is a vector, then it is called vector product

$$\mathbf{A} \times \mathbf{B} = AB\sin\theta\, n^{\wedge}$$

where n^ is normal to the plane containing vectors **A** and **B**.

Characteristics of vector product

- Cross product does not obeys commutative law
- $\vec{A} \times \vec{B} \neq \vec{B} \times \vec{A}$

- $\vec{A} \times \vec{A} = 0$, therefore, $\hat{i}, \times \hat{i}, = \hat{j} \times \hat{j} = \hat{k} \times \hat{k} = 0$
- $\vec{A} \times \vec{B} = AB\,\hat{n}$ if $\theta = 90°$, therefore, $\hat{i}, \times \hat{j} = \hat{k}, \hat{j} \times \hat{k} = \hat{i},, \hat{k} \times \hat{i}, = \hat{j}$
- $\vec{A} \times \vec{B} = -AB\,\hat{n}$ if $\theta = 270°$
- $m(\vec{A} \times \vec{B}) = (m\vec{A}) \times \vec{B} = \vec{A} \times m\vec{B}$
- $\vec{A} \times \vec{B} = \vec{0}$ if $\vec{A} \parallel \vec{B}$
- If the direction of any vector is reversed cross product becomes negative if both vectors are reversed no change in cross product.
- $\vec{A} \times \vec{B} = (A_yB_z - B_yA_z)\hat{i} + (A_zB_x - B_zA_x)\hat{j} + (A_xB_y - B_xA_y)\hat{k}$

OR

$$\mathbf{A} \times \mathbf{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

- Scalar triple product gives volume of parallelepiped.

Do You Know?

The vector product of two vectors gives the area of parallelogram.

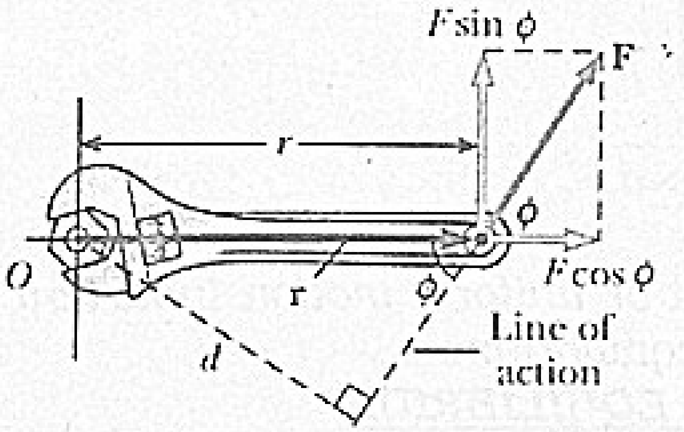
$$\vec{A} \cdot (\vec{B} \times \vec{C}) = A_x(B_yC_z - C_yB_z) - A_y(B_xC_z - C_xB_z) + A_z(B_xC_y - C_xB_y)$$

$$\mathbf{A} \cdot \mathbf{B} \times \mathbf{C} = \begin{vmatrix} A_x & A_y & A_z \\ B_x & B_y & B_z \\ C_x & C_y & C_z \end{vmatrix}$$

TORQUE

A physical quantity, which produces angular acceleration, is called torque.

- Dimensionally torque resembles with work.



- Torque is a vector quantity.

$$\vec{\tau} = \vec{r} \times \vec{F} = rF\sin\theta\,\hat{n}$$

- Magnitude of torque is given as;

$$\tau = rF\sin\theta$$
$$\tau = rF \qquad \text{if } \theta = 90°$$

- SI unit of torque is N-m.
- Torque is rotational analogue of force.
- Following factors affect torque:

Do You Know?

An inclined door automatically closes due to the torque produced by horizontal component of its weight.

1. Magnitude of force
2. Magnitude of position vector or point of application of force
3. Sine value of angle θ between $\vec{F}$ and $\vec{r}$.

- If line of action of force $\vec{F}$ passes through axis of rotation, then no torque is produced.
-

$$\tau = r\,F\sin\theta$$

OR $\tau = (r\sin\theta)\,F.$

$$\tau = r_\perp F$$

where $r_\perp$ is component of position vector perpendicular to force and $r_\perp = r\sin\theta$ is called *moment arm of torque.*

OR

$$\tau = r\,(F\sin\theta)$$

$$\tau = r\,F_\perp$$

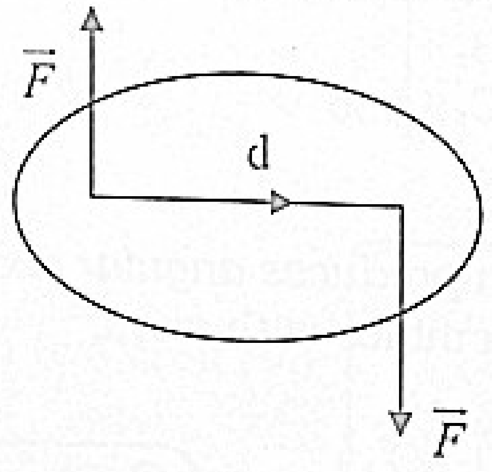
which shows that only perpendicular component of force contributes to torque and horizontal component does nothing in case of torque.

- If $\theta = 0°$ or π then $r_\perp = 0$ m and $F_\perp = 0$N so that $\tau = 0$ Nm.
- ***Direction alterations***

(a) If $\vec{F}$ is reversed, then direction of torque is also reversed.
(b) If $\vec{r}$ is reversed, then direction of torque is also reversed.
(c) If both $\vec{r}$ and $\vec{F}$ both are reversed then the direction of torque remains unchanged.

COUPLE

Two equal, opposite and non-collinear forces acting on a body constitute a couple.

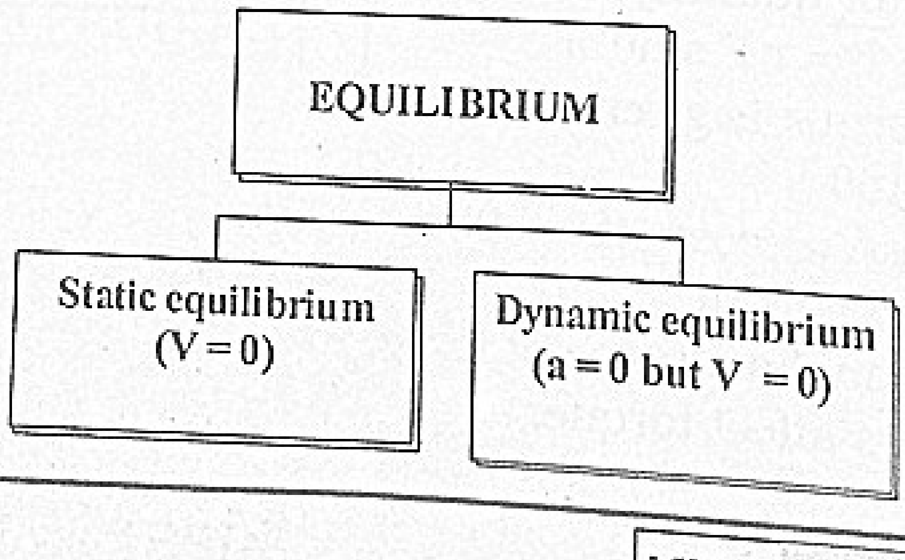


Couple = $\vec{F}\times\vec{d}$

EQUILIBRIUM

If a body keeps its state of rest or uniform motion invariant under many forces, it is said to be in perfect equilibrium.

KINDS OF EQUILIBRIUM



CONDITIONS OF EQUILIBRIUM

The conditions of equilibrium can be stated in terms of coplanar forces as follow:-

1st Condition of Equilibrium

The sum of forces acting on a body is equal to zero.

i.e.

$$\Sigma \overrightarrow{F_x} = 0$$

For coplanar forces

$$\Sigma \overrightarrow{F_x} = 0 \text{ and } \Sigma \overrightarrow{F_y} = 0$$

- 1st condition of equilibrium controls the translational equilibrium of the body.

2nd Condition of Equilibrium

The sum of torques acting on a body should be equal to zero. Mathematically

$$\Sigma \vec{T} = 0$$

Anticlockwise torque = clockwise torque

- 2nd condition of equilibrium controls the rotational equilibrium of the body.

Do You Know?

Both conditions of equilibrium must be fulfilled for a body to be in complete equilibrium weight.

PRACTICE EXERCISE

30 Time Minutes

(1) Rectangular coordinate system is also called
(a) polar coordinate system
(b) Cartesian coordinate system
(c) cylindrical coordinate system
(d) spherical coordinate system

(2) The direction of a vector in space is specified by
(a) one angle
(b) two angle
(c) three angle
(d) no angle

(3) Addition of vector obeys
(a) commutative law
(b) distributive law
(c) associative law
(d) all given laws in a, b and c

(4) Which of the following statement is correct about force and velocity
(a) force and velocity both are scalars
(b) force and velocity both are vectors
(c) Force is scalar and velocity is vector
(dy8) force is vector and velocity is scalar

(5) Unit vector n^ is along
(a) x-axis
(b) normal on a surface
(c) y-axis
(d) z-axis

(6) Cosθi^ + Sinθj^ is a
(a) vector
(b) position vector
(c) vector in the direction at angle θ with x-axis
(d) unit vector in the direction at angle θ with x-axis

(7) Maximum number of rectangular components are
(a) one
(b) two
(c) three
(d) infinite

(8) Maximum number of components of a vector may be
(a) one
(b) two
(c) three
(d) infinite

(9) Which one is not correct for a vector A=√2 i^+ √2 j^?
(a) has direction θ=45° with x-axis
(b) has magnitude 2
(c) has magnitude 2 and direction θ=45° with y-axis
(d) has magnitude -2

(10) The resultant of two forces of equal magnitudes is also equal to the magnitude of the forces. The angle between the two forces is
(a) 30°
(b) 60°
(c) 90°
(d) 120°

(11) What is the angle that the given vector makes with y-axis?
A= 2i^+√12 j^
(a) 30°
(b) 60°
(c) 90°
(d) 120°

KIPS

(12) In
san
(a)
(c)

(13) Two
pro
(a)
(c)

(14) Two
(a)
(c)

(15) If A
(a)
(c)

(16) Wh
(a)
(b)
(c)
(d)

(17) Wh
(a)
(c)

(18) Ou
(a)
(c)

(19) If e
un
(a)
(c)

(20) Nu
(a)
(c)

(21) Wl
(a)
(c)

(22) Ea
(a)
(c)

(23) Th
be
(a)
(c)

(24) Ar
fli
(a)
(c)

(12) In which quadrant the two rectangular components of a vector have same sign?
(a) 1st
(b) 2nd
(c) both 1st and 3rd
(d) 4th

(13) Two vectors A and B are making angle θ with each other. The scalar projection of vector B on vector A is written as
(a) A.B/A
(b) A.B/B
(c) A.cos θ
(d) both a and b are correct

(14) Two vectors are A = 3i^+2j^-k^& B= -3i^-2j^+k^, then
(a) B is anti parallel to A
(b) B is negative vector of A
(c) B has negative magnitude
(d) B is perpendicular to A

(15) If A=B, which of the following is not correct?
(a) A .B =A^.B^
(b) |A| = |B|
(c) |A^| = |B^|
(d) AB^ = BA^

(16) Which of the follwing is a scalar quantity
(a) the braking force needed to stop the car
(b) the heat needed to boil some water
(c) the effort needed to hammer a nail into wood
(d) the thrust needed to lift a rocket off the ground

(17) Which one is not a correct relation?
(a) $\vec{A}x\vec{B} = \vec{A}x\vec{B}$
(b) |AxB| = -|BxA|
(c) AxB = AB Sinθn^
(d) BxA = AB Sinθ(-n^)

(18) Out of the following set of forces, the resultant of which cannot be zero
(a) 10,10,10
(b) 10,10,20
(c) 10,20,40
(d) 10,20,20

(19) If east, west, north, south, up and down are representing the direction of unit vectors, then east x south has direction along
(a) west
(b) north
(c) down
(d) up

(20) Null vector is a vector which has
(a) zero magnitude
(b) no specified direction
(c) both a and b are correct
(d) both a and b are not correct

(21) Which one is a unit vector?
(a) $\sqrt{3}$ i^ + $\sqrt{3}$ j^+ $\sqrt{3}$ k^
(b) 1/$\sqrt{3}$ i^ + 1/$\sqrt{3}$ j^+ 1/$\sqrt{3}$ k^
(c) $\sqrt{3}$/3 i^ + $\sqrt{3}$/3 j^+ $\sqrt{3}$/3 k^
(d) both b and c are correct

(22) Easy method to determine angle between two vectors A and B is
(a) their dot product
(b) their cross product
(c) head to tail rule
(d) right hand rule

(23) The magnitude of cross product of two vectors is equal to the dot product between them. The angle between the two vectors is
(a) 30°
(b) 45°
(c) 60°
(d) 180°

(24) An airplane flies 400m from north and the flies 300m south and then flies 1200m upwards then net displacement is
(a) 1500m
(b) 1200m
(c) 900m
(d) 700m

(25) A vector contains more information than scalar, what is this extra information

(a) acceleration (b) direction

(c) size (d) resultant

(26) Five equal forces of 10N each are applied at one point and all are lying in one plane. If the angles between them are equal, the resultant force will be

(a) 10N (b) 20N

(c) $10\sqrt{2}$ N (d) zero

(27) Torque acting on a body determines

(a) acceleration (b) linear acceleration

(c) angular acceleration (d) direction of motion of the body

(28) The dimension of torque

(a) $[MLT^{-1}]$ (b) $[ML^2T^{-1}]$

(c) $[ML^2T^{-2}]$ (d) $[ML^2T]$

(29) A body will be in complete equilibrium when it is satisfying

(a) Ist condition of equilibrium

(b) 2nd condition of equilibrium

(c) both Ist and 2nd condition of equilibrium

(d) impossible

(30) A body in equilibrium is

(a) at rest (b) in motion

(c) at rest or in uniform motion (d) all are correct

(31) Three coplanar forces acting on a body keep it in equilibrium. They should therefore be

(a) concurrent (b) non concurrent

(c) parallel (d) non parallel

(32) Which of the following pairs does not have identical dimensions?

(a) torque and energy (b) momentum and impulse

(c) energy and work (d) mass and moment of inertia

(33) A central force is that which

(a) can produce torque

(b) can't produce torque

(c) some time can produce torque some time can't

(d) has no relation with torque

(34) It is easier to turn a steering wheel with both hands than with a single hand because

(a) accelerating force increases on the wheel

(b) two forces act on the wheel

(c) two hands provide firm grip

(d) couple acts on the wheel

(35) A force of 10N is acting along y-axis. Its component along x-axis is

(a) zero (b) 10N

(c) 100N (d) 5N

(36) The unit vector in the direction of vector $\overrightarrow{A} = 2\hat{i}-2\hat{j}+\hat{k}$ is

(a) $[2\hat{i}-2\hat{j}+\hat{k}\ ]$/(b)

(b) $(2\hat{i}-2\hat{j}+\hat{k})/\ 9$

(c) $(2\hat{i}-2\hat{j}+\hat{k})/\ 3$

(d) $(2\hat{i}-2\hat{j}+\hat{k})/\ 5$

(37) The magnitude of i^.(j^ x k^) is

(a) 0

(b) 1

(c) –1

(d) i^

(38) In which quadrant, only value of 'tan' will be positive?

(a) first

(b) second

(c) third

(d) both 1st and 3rd

(39) If $\vec{A} = A_x\,\hat{i} + A_y\,\hat{j} + A_z\,\hat{k}$ $\quad \vec{B} = B_x\,\hat{i} + B_y\,\hat{j} + B_z\,\hat{k}$ then

(a) $\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$

(b) $\vec{A}\cdot\vec{B} = A_xB_y + A_yB_z + A_zB_y$

(c) $\vec{A}\cdot\vec{B} = A_yB_z + A_zB_y + A_zB_x$

(d) $\vec{A}\cdot\vec{B} = A_xB_z + A_yB_y + A_zB_x$

(40) The cross product of two vectors is zero when

(a) they are parallel vectors

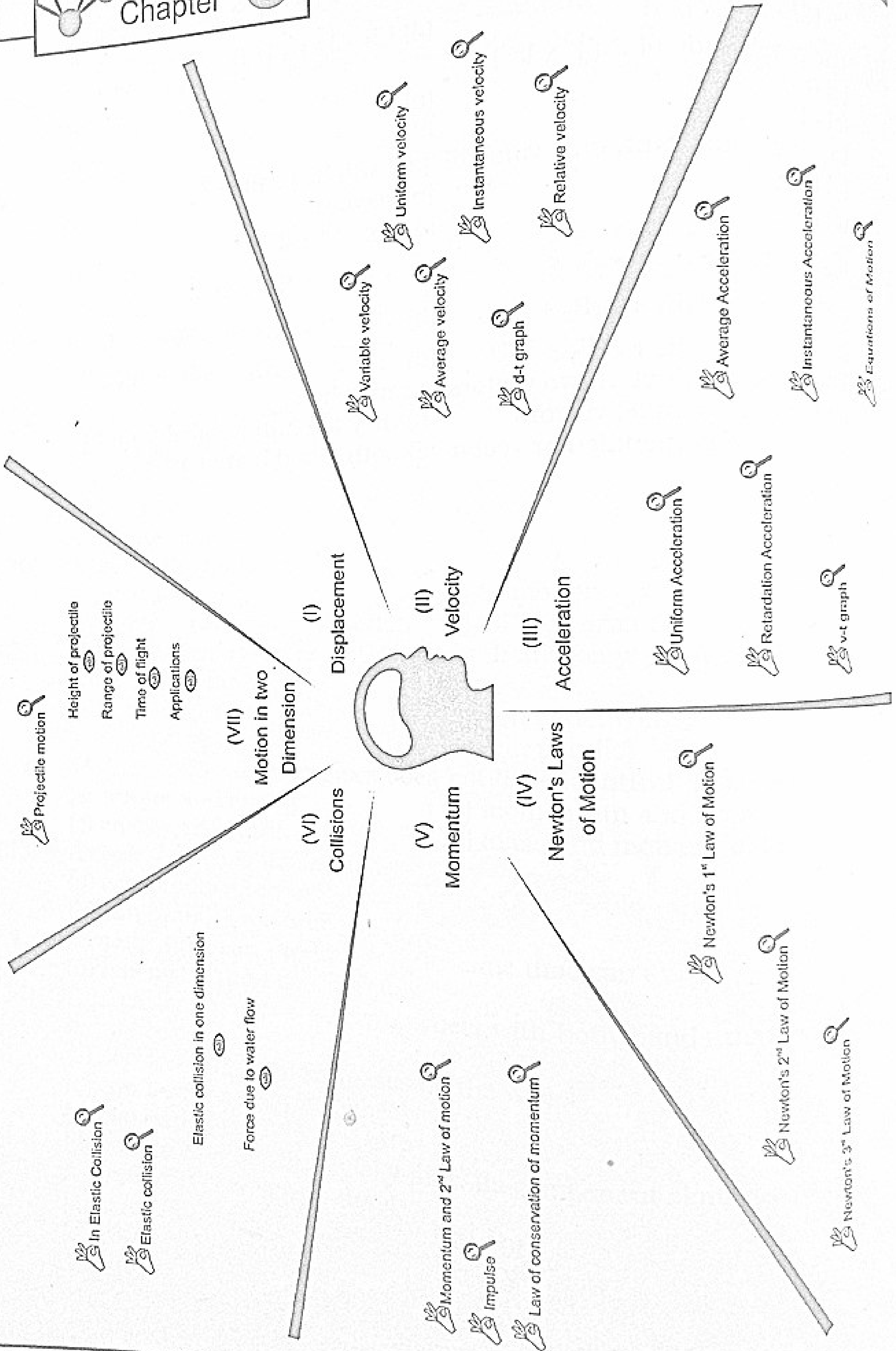
(b) they are anti parallel vectors

(c) they are perpendicular vector

(d) both a and b are correct

Chapter 3

Motion and Force



INTRODUCTION

The concept of state of motion and rest are described relative to the observer.

- If a body does not change its state w.r.t surroundings, it is in the state of rest.
- If a body changes its state w.r.t surroundings, then it is in the state of motion.

A moving body can posses both states of rest and motion, depending on the observer.

DISPLACEMENT

Displacement is a vector that depicts the change in the position of body from initial to final position.

DISTANCE

The length of the path between two points is called distance.

Do you know?

When a body moves along straight line then the displacement coincides with the distance traveled.

SPEED	VELOCITY
○ **The ratio of distance covered by a body to the time taken is called speed.** ○ **Scalar quantity.**	○ **Time rate of change of displacement is called velocity.** ○ **Vector quantity.**

Both have dimensions $[LT^{-1}]$ and are measured in $m.s^{-1}$

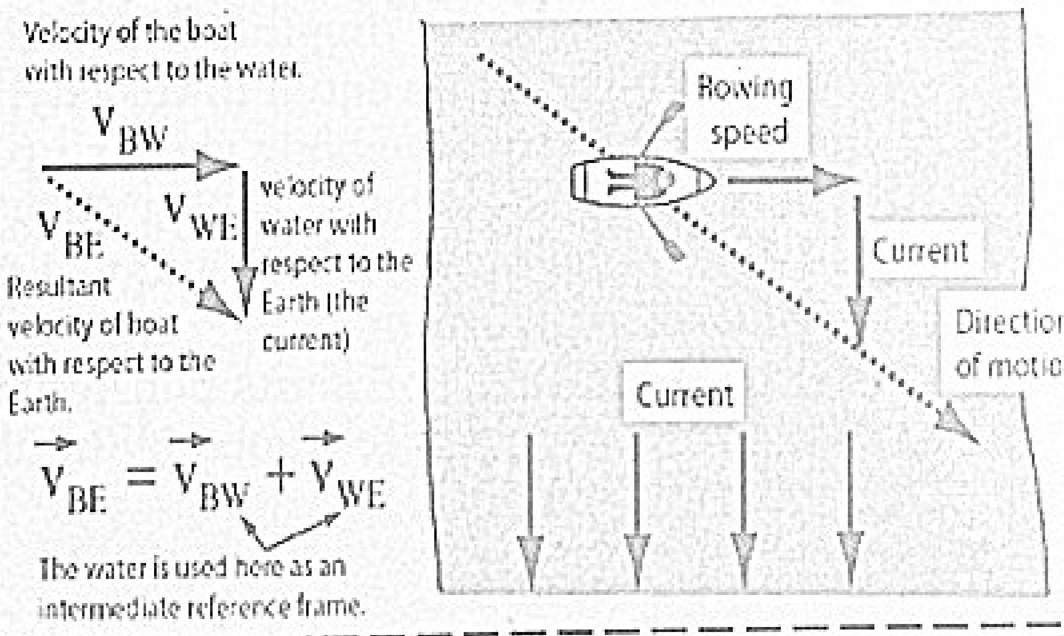
Their classification is as follow:-

Do you know?

For a body moving with uniform speed, Its instantaneous and average speeds are equal to each other.

Information

A boat in current is a good example of relative velocity.

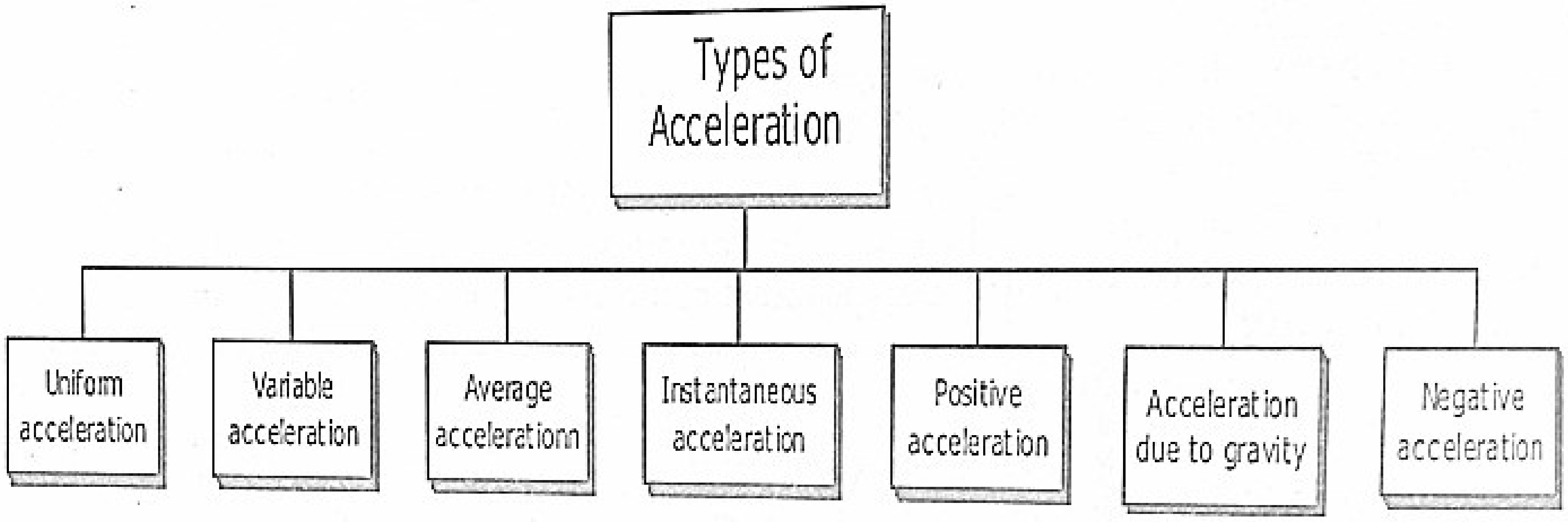

Velocity of the boat with respect to the water.
V_{BW}
V_{BE}
V_{WE}
velocity of water with respect to the Earth (the current)
Resultant velocity of boat with respect to the Earth.
The water is used here as an intermediate reference frame.
Rowing speed
Current
Current
Direction of motion

$$\vec{V}_{BE} = \vec{V}_{BW} + \vec{V}_{WE}$$

ACCELERATION

Rate of change of velocity is called acceleration. $a = \frac{\overrightarrow{\Delta v}}{\Delta t}$

- Acceleration may be produced by the variation of:
  (a) magnitude of velocity i.e. speed
  (b) direction of velocity
  (c) both magnitude and direction of velocity.



- *Acceleration is a vector quantity measured in $m.s^{-2}$. Its dimensions are $[LT^{-2}]$*

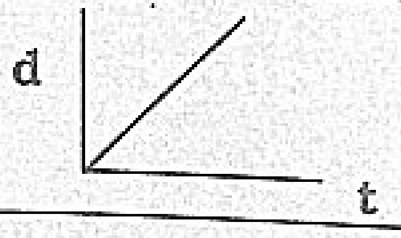
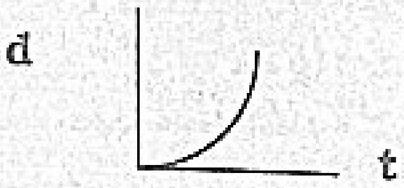
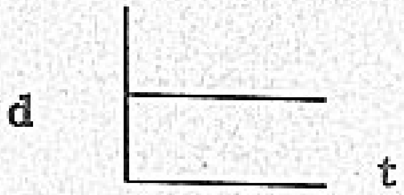
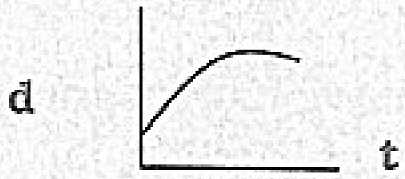
If the velocity of body reduces but not to zero, then negative acceleration is called **deceleration** but if the velocity reduces to zero, then negative acceleration is called **retardation.**

GRAPHS

Graph is a pictorial display between two dependent quantities.

Displacement-Time Graph

- d-t graph shows relation between displacement and time.
- d-t graph contains following information;
  1. Slope of the graph is equal to velocity.
  2. If slope increases, the body speeds up.
  3. If slope decreases, the body slows down.
  4. If d-t graph is straight line, parallel to time axis, the body will be at rest (static equilibrium).
  5. Zigzag, d-t graph represents non-uniform velocity.
  6. Instant velocity is determined by finding slope of tangent to d-t graph at that point.

Graph Shape	Slope	Velocity
	Constant positive	Velocity is constant
	positive	Velocity is increasing
	Constant (zero)	Velocity is zero
	negative	Velocity decreases

Velocity-Time Graph

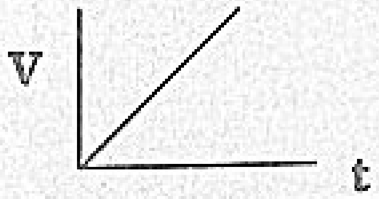
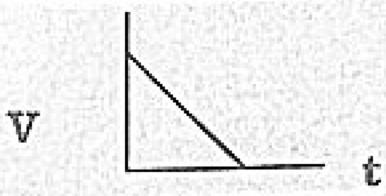
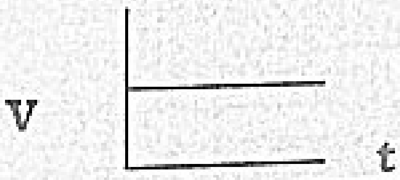
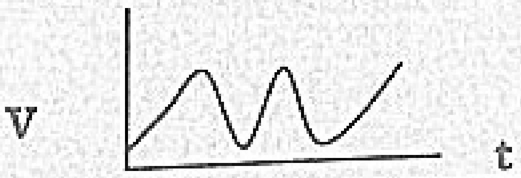
Velocity time relationship is expressed by graph by plotting statistical data on x-y plane taking velocity along ordinate and time along abscissa.

Salient Features

- The slope of velocity time graph gives acceleration i.e.

$$\vec{a} = \frac{\Delta \vec{V}}{\Delta t} = \tan\theta = \text{Slope of graph.}$$

- The area under the v-t growth gives the distance covered by object.

Graph Shape	Slope	Acceleration
	Constant positive	Acceleration uniform
	Constant negative	Is uniform deceleration
	Constant (zero)	Acceleration is zero.
	Variable	Body is moving with variable acceleration.

TOP Study

EQUATIONS OF MOTION(BY GALILEO)

$V_f = V_i + at$ or $V_f = V_i + gt$

$S = V_it+1/2at^2$ or $S = V_it+1/2gt^2$

$V_f^2 = V_i^2 + 2as$ or $V_f^2 = V_i^2+2gs$

NEWTON'S LAWS OF MOTION

- Newton's work on physics in his book named ***PRINCIPIA** of **mathematics***.
- Newton's law applicable for moving objects having speed not comparable to the speed of light.

1st law (law of inertia)

If $\Sigma F = 0$, then $a = 0$

2nd law

$\Sigma \vec{F} = m\vec{a} \Rightarrow a_1/a_2 = m_2/m_1$

3rd law

$\vec{F}_{AB} = -\vec{F}_{BA}$ or $\vec{F}_{action} = -\vec{F}_{reaction}$

- Action and reaction forces never acts on the same body.

Inertial Frame

They are at rest or moving with uniform relative velocity. Law of inertia hold in these frames.

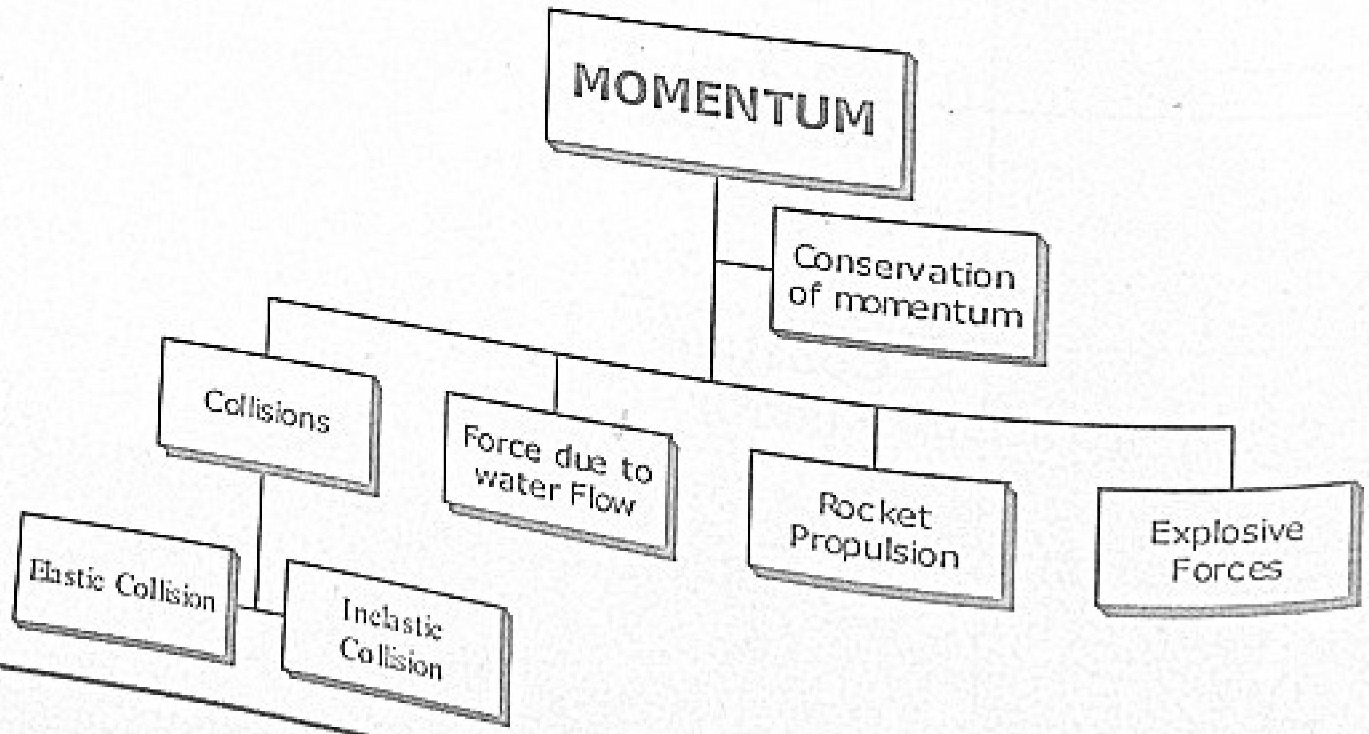
Non Inertial Frame

The are not moving with uniform relative velocity. Law of inertia not hold in these frames.

Applications

- Weight is a force with which a body is attracted towards the center of earth.
- Earth is an approximate inertial frame of reference because it has small negligible angular acceleration.
- In zero force environment only inertial observer can sit.
- Swimming in a water pond.
- Driving a car on road.
- Mass measurement independent of gravity.

MOMENTUM



Linear momentum

It is a characteristic equal to mass times velocity.

$$p = mv$$

- Linear momentum is a vector quantity and has direction.
- Linear momentum depends upon

$P \alpha v$ $p \alpha m$

- $p = 0$ if $V = 0$, how massive the body may be.
- *SI unit of linear momentum are kg m.s^{-1} or Ns. Dimension of momentum are [MLT^{-1}]*

Impulse

If neither force nor its time of action is known (mostly due to its shortness), then we define impulse of force as;

$$\vec{I} = \Delta \vec{p} = \vec{F} \cdot \Delta t$$

- Dimensionally $\vec{I}$ is same that of linear momentum.
- Inertial mass is quantitative measurement of acceleration produced.
- Time rate of change of momentum is equal to the applied force.
- Change in momentum is equal to the impulse of the body.

> **Point to Ponder**
>
> The thermopore pieces inside the dinner sets protect the cups or other items from fracturing. Why?

Law of conservation of linear momentum

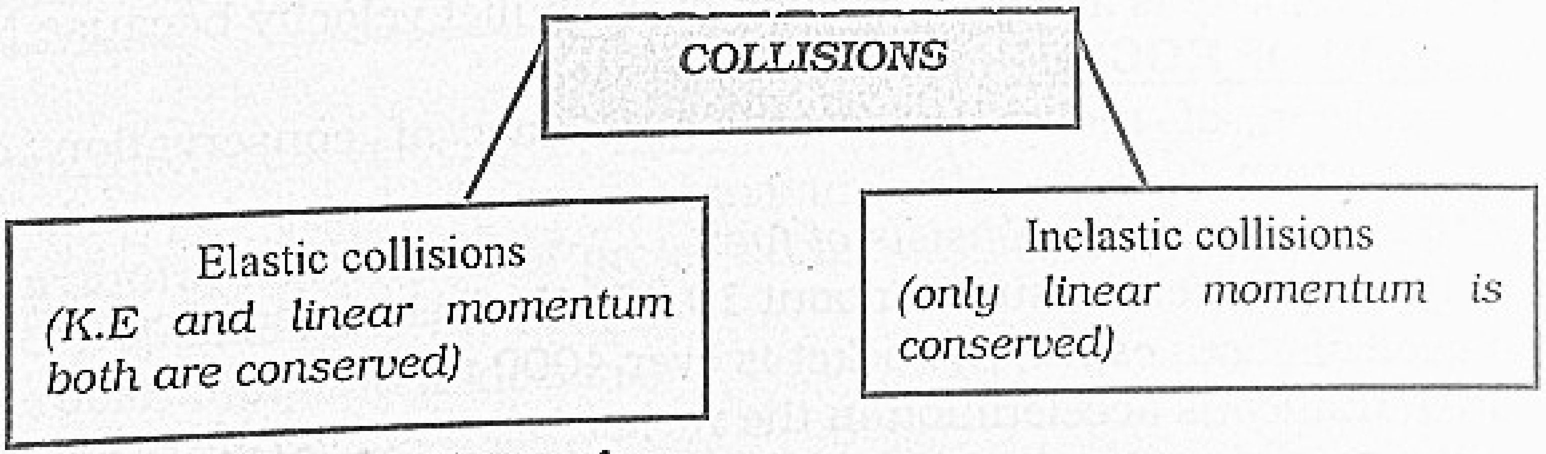
In an isolated system $(P_i)_{total} = (P_f)_{total}$

$$m_1v_1+m_2v_2 = m_1v_1+m_2v_2$$

- The sum of change in momentum for two colliding bodies is zero.
- The total linear momentum of an isolated system remains constant.

COLLISIONS

Collision is said to be taken place if some sort of interaction appears between bodies due to their closeness.


COLLISIONS
Elastic collisions
(K.E and linear momentum both are conserved)
Inelastic collisions
(only linear momentum is conserved)

Elastic collision in one dimension

- Elastic collision in one dimension is that one, in which colliding bodies do not deviate from their line of motion, after the collision.
- In case of bodies undergoing elastic collision in one dimension.

$$V_1 + V'_1 = V_2 + V'_2$$

or $$V_1 - V_2 = -(V'_1 - V'_2).$$

Speed of approach = Speed of recession

After collision,

$$V'_1 = (m_1 - m_2)V_1/(m_1+m_2) + 2m_2V_2/(m_1+m_2)$$

$$V'_2 = 2m_1V_1/(m_1+m_2) + (m_2 - m_1)V_2/(m_1+m_2)$$

Cases of elastic collision

Case I: If $m_1 = m_2$ & $V_2 \neq 0$

then $V'_1 = V_2$ & $V'_2 = V_1$

Case II: If $m_1 = m_2$ & $V_2 = 0$

then $V'_1 = 0$ & $V'_2 = V_1$

In both cases I & II due to the same masses of the colliding bodies their velocities after collision got interchanged.

Case III: If $m_1 >> m_2$ & $V_2 = 0$

then $V'_1 = V_1$ & $V'_2 = 2V_1$

Case IV: If $m_1 << m_2$ & $V_2 = 0$

then $V'_1 = -V$ & $V'_2 = 0$

FORCE DUE TO WATER FLOW

Water exerts force on a wall, when impinges over it. This force is equal to the product of mass flow rate of water and its velocity.

i.e. $$\vec{F} = \frac{m}{t}\vec{V}$$

The above phenomenon gives us an idea to invent turbines that uses hydral energy.

MOMENTUM & EXPLOSIVE FORCES

For exploding bomb, the momenta of the fragments combined by vector addition are equal to the initial momentum of the falling bomb.

- During explosion law of conservation of momentum holds well. The recoil velocity of a rifle (M,V) fired from a bullet (m,v) is
$$V = \frac{-m}{M}v$$
- Recoil velocity is always a fraction of the bullet velocity because M>m.

PROPULSION OF ROCKET

- Propulsion of rocket is according to law of conservation of linear momentum
- *80% mass of rocket consists of fuel.*
- A typical rocket consumes about 10,000 Kg fuel in one second.
- Speed of gases expels by rocket is over 4000 m/s.
- Instantaneous acceleration in the rocket is $a = mv/M$
Where

m = mass of the gases ejected per second
M = mass of the rocket
V = velocity of ejected gases

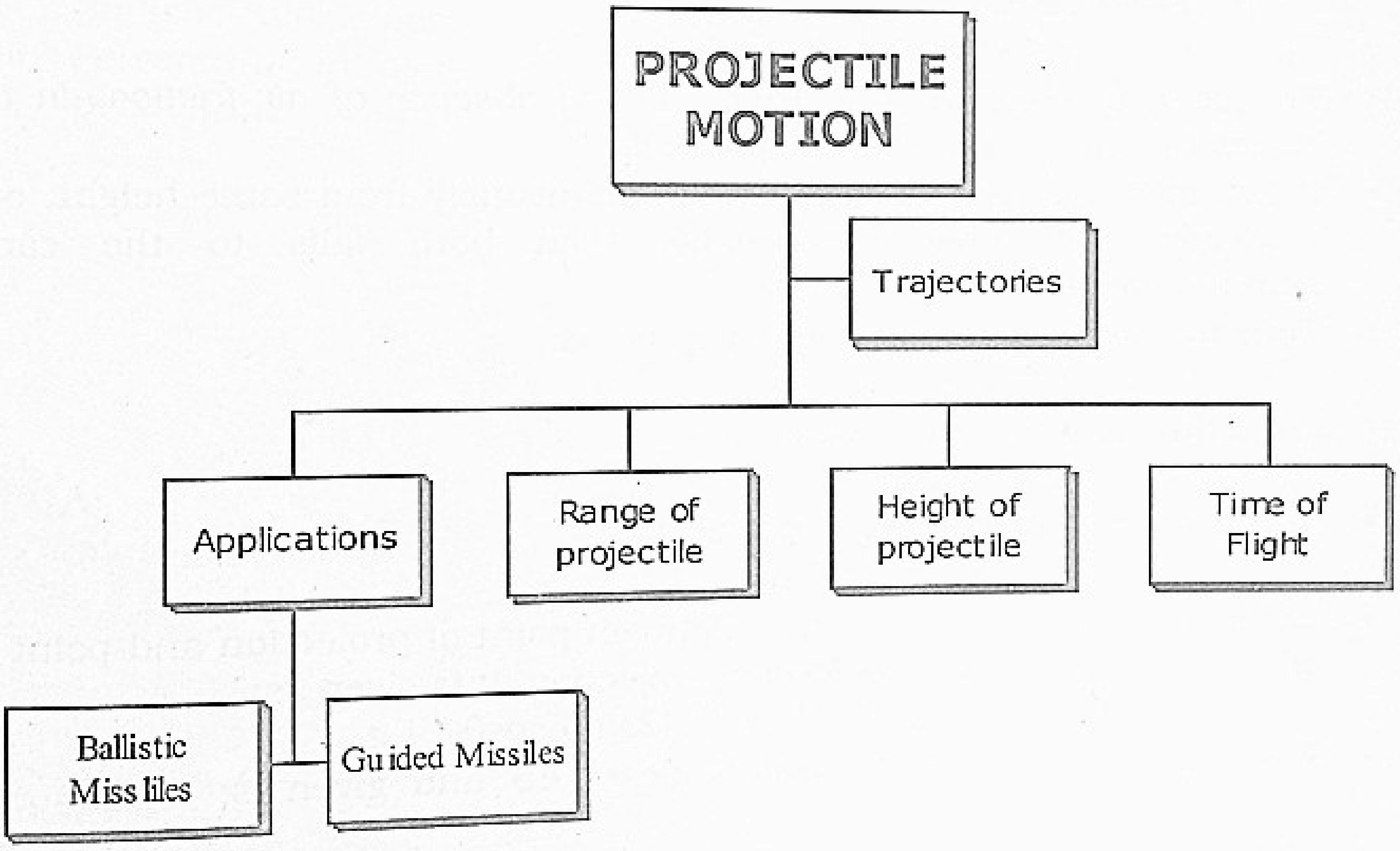
Do you know?

The rockets are made in several compartments. When a compartment emptied from fuel it is dropped, thus reducing the overall mass of rocket and hence increasing the acceleration of rocket.

Assumptions for the Derivation of Equations of projectile

- *Earth is assumed to be flat over the whole trajectory of projectile.*
- *The acceleration due to gravity remains constant over the whole trajectory of projectile.*
- *Neglecting the aerodynamics effects.*
- *Considering the horizontal thrust force as zero i.e. assuming horizontal velocity to be constant.*

PROJECTILE MOTION



- Instantaneous velocity is maximum at point of projection and at the landing point and minimum at maximum height as $V_y=0$.
- Horizontal component of projectile velocity remains constant throughout the projectile motion.
- Vertical component decreases, becomes zero at maximum height and then increases till projectile hits the ground.

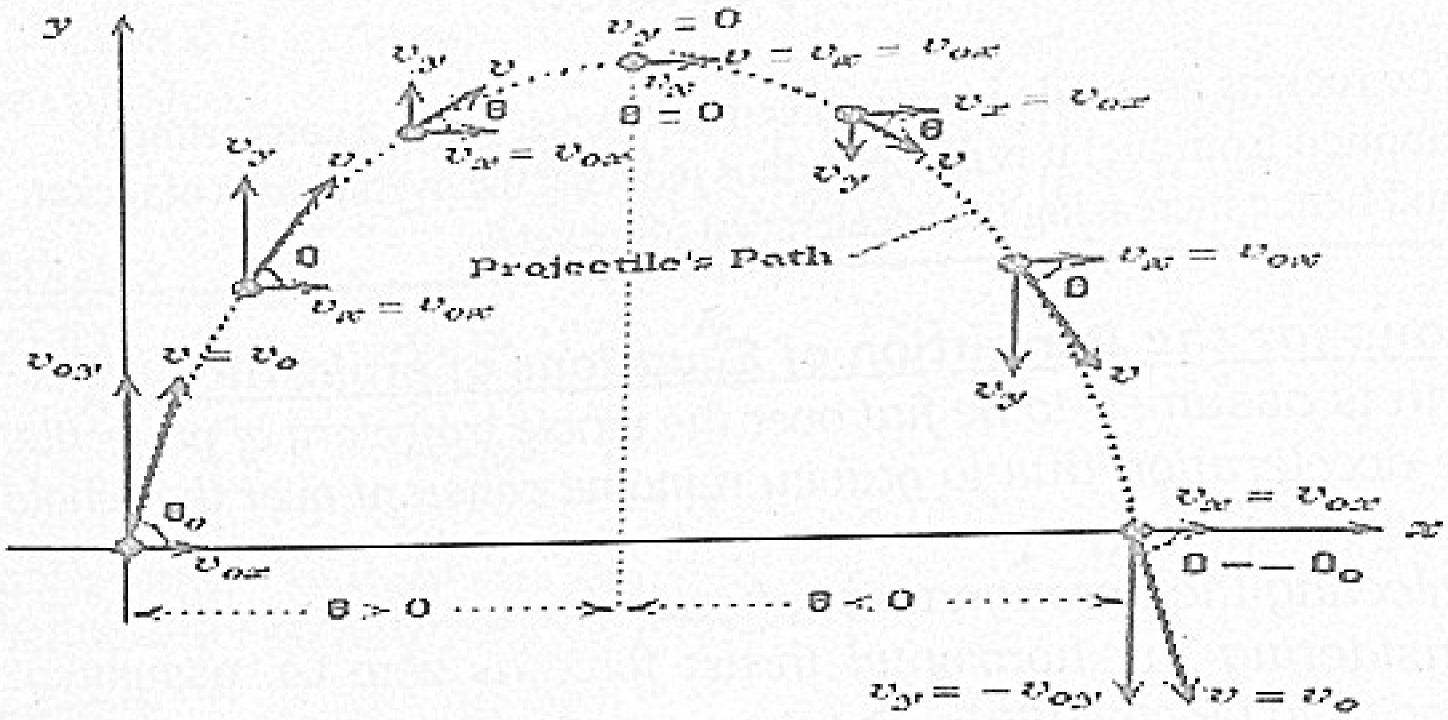
Note that

$\overline{a_x}=0$

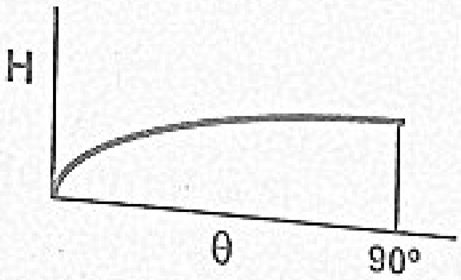
$\overline{a_y}=\pm g$

R = Range of projectile

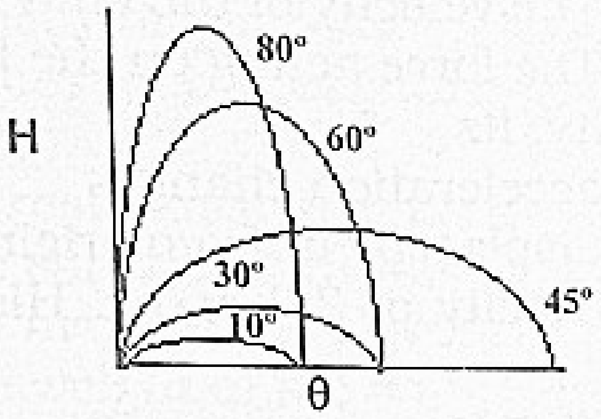
H = Maximum Height of projectile.



- Horizontal and vertical coordinates of projectile at time 't' are given as;
  $$x = V_0 \cos\theta_0 \, t$$
  $$y = V_o \sin\theta_0 \, t - 1/2gt^2$$
- *Trajectory of projectile is parabola in the absence of air friction. In the presence of air friction it is like parabola.*
- If two identical balls are thrown simultaneously from same height, one vertically and other horizontally, then both falls to the earth simultaneously.
- Time to reach maximum height is given as;
  $$t = V_0 \sin\theta_0/g$$
- Total time of flight is given as;
  $$T=2V_0 \sin\theta_0 / g$$
- Vertical range (height) is given as;
  $$H = V_0^2 \sin^2\theta_0/2g$$
- Range (horizontal) is a distance between point of projection and point at which it comes back to its level of projection. It is given as;
  $$R = V_0^2 \mathrm{Sin}2\theta_0/g = V_0^2 (2\sin\theta_0\cos\theta_0) / g$$
- Maximum horizontal range is at angle θ = 45° and given as;
  $$R = V_0^2/2g$$
- The relation between range and the height of the projectile is
  $$R\tan\theta = 4H$$
- ***Variation of height of the projectile with angle***



- With same initial velocity the range of projectile for two angles of projection will be equal if sum of the angles is equal to 90° i.e. $\theta_1 + \theta_2 = 90°$
- Variation in the range and height with angle is shown with the following sketch



Do you know?

When angle of projection is 76° then range and height of projectile are equal to each other.

Application to Ballistic Missile

- An **un-powered** and **un-guided** missile is called *ballistic missile*
- Friction of air effects the horizontal and vertical motion of the missile
- *Ballistic missiles are useful only for short ranges.*
- *Powered and remote control guided missiles are used for long ranges and* ***precision.***

PRACTICE EXERCISE

30 mins Time Yourself

(1) What must change when a body is accelerating?
(a) The mass of the body (b) The velocity of the body
(c) The speed of the body (d) The force acting on the body

(2) A body is moving with uniform velocity. Its
(a) speed changes (b) acceleration changes
(c) direction of motion changes (d) displacement from origin changes

(3) A man is in a car is moving with velocity of 36Km/hr. His speed with respect to the car is
(a) 10m/s (b) 36m/s
(c) zero (d) infinite

(4) When velocity time graph is a straight line parallel to time axis then
(a) acceleration is const (b) acceleration is variable
(c) acceleration is zero (d) velocity is zero

(5) A body is moving in a circle at a constant speed. Which of the following statement is true about the body
(a) There is no acceleration
(b) There is a force acting at a tangent to a circle
(c) There is a force acting away from the center of the circle
(d) There is a force acting towards the center of the circle

(6) When a person walk along east, the force of friction is along
(a) east (b) west
(c) anywhere from east to west (d) anywhere from north to south

(7) Instantaneous and average velocities become equal when body
(a) has zero acceleration (b) has uniform acceleration
(c) has variable acceleration (d) moves in a circle

(8) Which law of motion is also called law of inertia?
(a) 1st law (b) 2nd law
(c) 3rd law (d) all 1st, 2nd and 3rd laws

(9) When a horse pulls a cart, the force that makes the horse run forward is the force exerted by
(a)the horse on the ground (b) the cart on the ground
(c) the ground on the horse (d) the ground on the cart

(10) Newton's laws do not hold good for particles
(a) at rest
(b) moving slowly
(c) move with high velocity
(d) move with velocity comparable to velocity of light

(11) 1st law of motion gives the definition of
(a) rest (b) motion
(c) velocity (d) force

(12) 2nd law of motion gives the information about a quantity
(a) force (b) acceleration
(c) velocity (d) both force and acceleration

(13) 3rd law of motion explains
(a) effect of force
(b) existence of a force
(c) existence of two forces
(d) existence of pair of forces in nature

(14) Momentum depends upon
(a) force acts on the body
(b) mass of the body
(c) velocity of the body
(d) both mass and velocity of the body

(15) Why does an object falling in the earth's gravitational field reach a steady velocity
(a) air resistance increases with increase in velocity
(b) the earth's gravitational field decreases as the object falls
(c) the mass of the object remains constant
(d) the weight of the object increases as it falls

(16) When a body moves in a straight line then its displacement coincides with
(a) distance
(b) force
(c) acceleration
(d) both (a) and (b)

(17) When two bodies stick together after collision, the collision is said to be
(a) perfectly elastic
(b) partially elastic
(c) completely inelastic
(d) none of these

(18) Motorcycle safety helmet extends the time of collision hence decreasing the
(a) chance of collision
(b) force acting
(c) velocity
(d) impulse

(19) The collision between two bodies be elastic if bodies are
(a) solid and soft
(b) soft and elastic
(c) solid and hard
(d) hard and elastic

(20) At maximum height on trajectory which of projectile becomes zero
(a) acceleration
(b) velocity
(c) vertical velocity
(d) horizontal velocity

(21) When car takes turn around a curve road, the passengers feel a force acting on them in a direction away from the center of the curve. It is due to
(a) centripetal force
(b) gravitational force
(c) their inertia
(d) centrifugal force

(22) A body is falling freely under gravity. How much distance it falls during an interval of time between 1st and 2nd seconds of its motion, taking $g=10$?
(a) 10 m
(b) 15 m
(c) 20 m
(d) 25 m

(23) What is the shape of velocity time graph for constant acceleration?
(a) straight inclined line.
(b) parabola
(c) inclined curve
(d) declined curve

(24) When collision between the bodies in a system is inelastic in nature then for the system
(a) momentum changes but K.E remain conserve
(b) K.E changes but momentum remain conserve
(c) both momentum and K.E changes
(d) both momentum and K.E remain conserve

(25) Which shows the correct relation between time of flight T and maximum height H?

(a) $H=gT^2/8$ (b) $H=8T^2/g$

(c) $H=8g/T^2$ (d) $H=8/gT^2$

(26) If an iron ball and wooden ball of the same radius was released from the height 'h' in vacuum, then time taken by both of them to reach the ground will be

(a) Unequal (b) Equal

(c) zero (d) none of these

(27) Taking off rocket can be explained by

(a) 1st law of motion

(b) 2nd law of motion

(c) law of conservation of momentum

(d) law of conservation of energy

(28) Which of the following is not an example of projectile motion.

(a) a gas filled balloon (b) bullet fired from gun

(c) a football kicked (d) a base ball shot

(29) What is the angle of projection for which the range and maximum height become equal?

(a) $\tan^{-1} 1/4$ (b) $\tan^{-1} 4$

(c) $\tan^{-1} 1/2$ (d) $\tan^{-1} 2$

(30) The thrust on the rocket in the absence of gravitational force of attraction is

(a) constant

(b) not constant

(c) constant if the rate of ejected gases is constant

(d) constant for short range rocket.

(31) When two bodies move toward each other with constant speeds the distance between them decreases at the rate of 6m/sec. If they move in the same direction the distance between them increases at the rate of 4m/sec. Then their speeds are

(a) 5m/s, 1m/s (b) 3m/s, 3m/s

(c) 6m/s, 1m/s (d) 4m/s, 2m/s

(32) Distance covered by a freely falling body in 2 seconds will be

(a) 4.9m (b) 19.6m

(c) 39.2m (d) 44.1m

(33) The distance covered by a body in time 't' starting from rest is

(a) $at^2/2$ (b) Vt

(c) $a^2t/2$ (d) at^2

(34) Flight of a rocket in the space is an example of

(a) second law of motion (b) third law of motion

(c) first law of motion (d) law of gravitation

(35) The trajectory (or path) of a projectile is

(a) straight line (b) parabola

(c) hyperbola (d) circle

(36) Rocket engine lifts rocket from the earth's surface, because hot gas with high velocity

(a) react against the rocket and push it up
(b) push against the air
(c) push against the earth
(d) heat up the air which lifts the rocket

(37) The force beard by a wall on which water strikes normally at a speed of 10m/sec and at a discharge of0.0001m³/sec is.

(a) 1N (b) 10N
(c) 100N (d) none

(38) Time rate of change of momentum is equal to

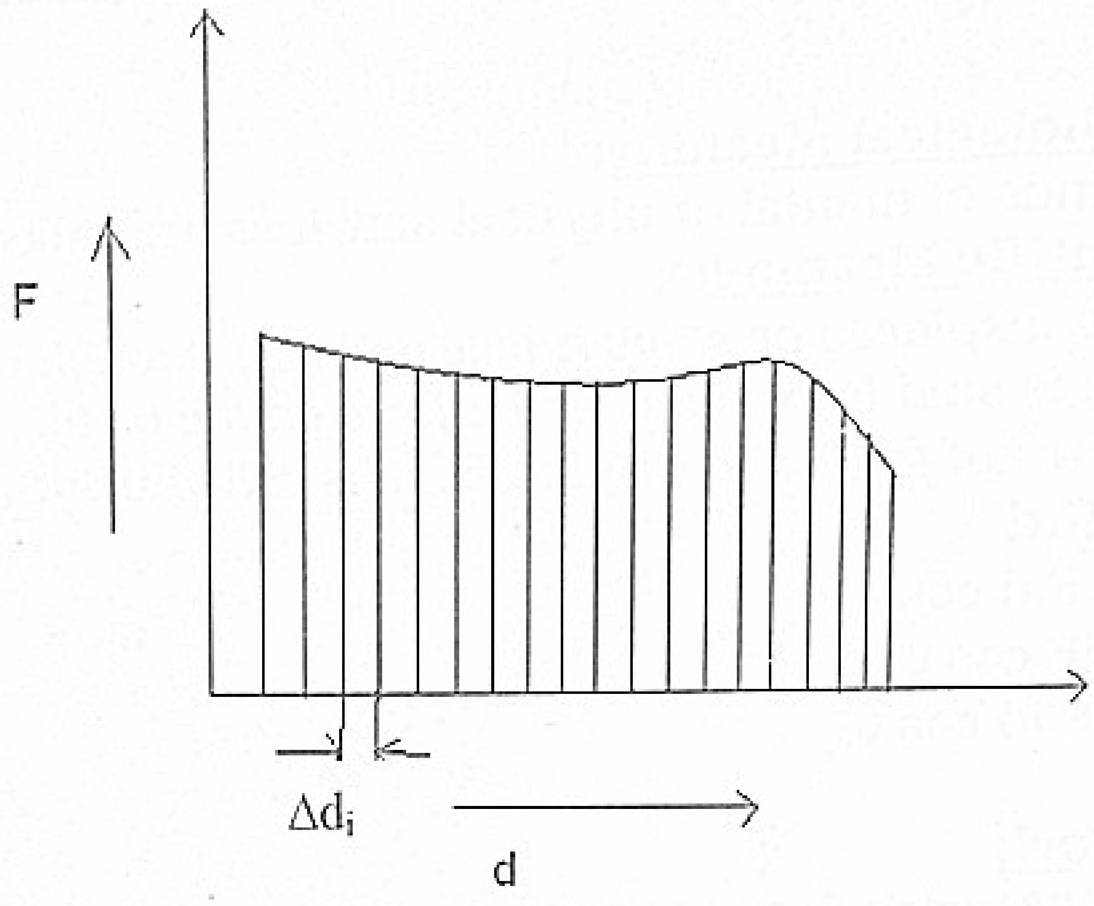
(a) force (b) impulse
(c) velocity (d) both (a) and (c)

(39) The range of the projectile at 30° is R_{30} and at 60° is R_{60} then

(a) $R_{30} = R_{60}$ (b) $R_{30} = 2R_{60}$
(c) $2R_{30} = R_{60}$ (d) $R_{30} = R_{60}$ if initial velocities are same

(40) Why Ballistic missile fails in some circumstances of precision.

(a) due to their shape (b) due to air resistance
(c) due to angle of projection (d) all of these



(b) Work done by a variable force.

$$\text{Total Area} = \text{Lim} \sum_{i=1}^{n} F_i \text{Cos}\theta_i \Delta d_i = \text{work done}$$

CONSERVATIVE FIELD

- Gravitational acceleration is denoted by $\overrightarrow{g}$ whose magnitude is $9.8 m/s^2$ and direction is vertically downward.
- If a field satisfies following two conditions, it is said to be conservative.
  1- Work done along a closed path is zero i.e. $W_{total} = 0$
  2- Work done is independent of path followed by body but depends on final and initial position of a body.
  Example: Electric field, Gravitational field.
- Frictional force is non-conservative force. Other non-conservative forces are propulsion force on rocket, force of a motor, tension in string etc.

POWER

Time rate of doing work is called power.

Power = work/time

- *In linear motion,* power is given as;
  $P = W/t = \overrightarrow{F} \cdot \overrightarrow{V}$
- *In angular motion,* power is given as;
  $P = \vec{\tau} \cdot \vec{\omega}$
- *Average power* is given as;
  $\langle P \rangle = \langle W \rangle / t$
  $= F_{av} \, d/t$

Do you know?

A person having more power than other person does not means that he has more energy as well. Reverse is also true.

- *Instantaneous power* is given as;

$$p = \underset{\Delta t \to 0}{Limit} \Delta w / \Delta t$$

- If <P> = P_{int}, then body does work at constant rate.
- Unit of power is watt defined as;

  $$1\,W = 1\,J/1\,sec$$

- *Dimensionally power is equivalent to* $[ML^2T^3]$
- *1 h.p = 746 watt = 550 foot pound/sec*
- *Commercial unit of electricity is KWH*

  $$1KWh = 3.6*10^6\,J$$

Do you know?

If a spring is compressed then work done on its equals the increase in its elastic potential energy.

Work energy Principle

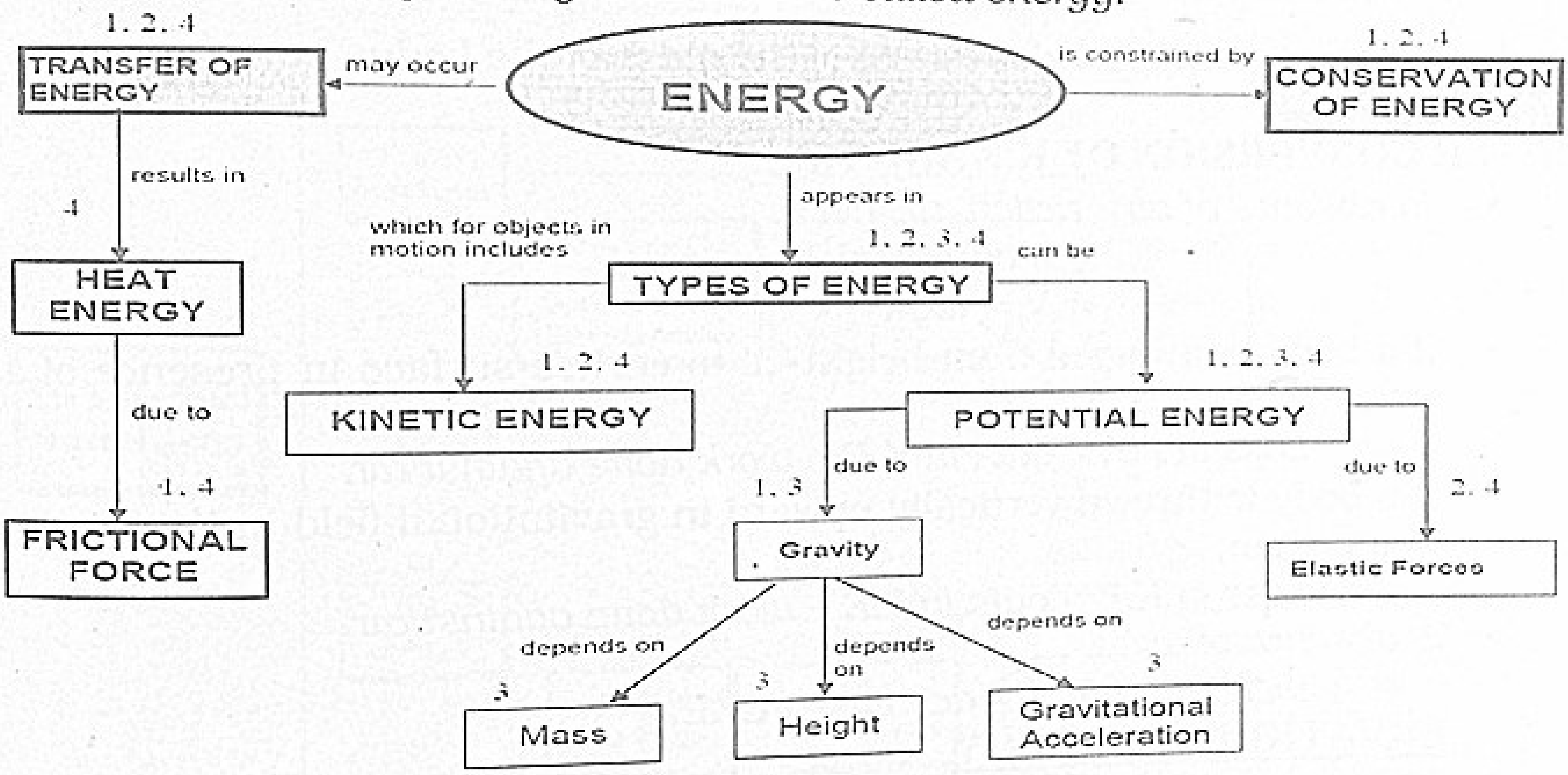
"Work done on the body equals change in its K.E"

i.e.

$$Work = (K.E)_f - (K.E)_i$$

ENERGY

Ability of a body to do work is called energy.



Forms of energy

Name	Definition	Formula
K.E	*Ability of a body to do work due to motion*	$1/2\,mV^2 = p^2/2m$ *P=momentum*
Gravitational P.E	*Ability of a body to do work due to position in gravitational field*	$m\,g\,h$
Elastic P.E	*Ability to do work due to elasticity*	$kx^2/2$
Electric P.E	*Ability of a body to do work due to position in electric field*	$q\Delta v$

Applications of Gravitational P.E

- Absolute gravitational P.E of a body on surface of earth is given as

  $$U_m = -\frac{GmM}{R}$$

TOP Study

- Negative sign due to selecting the zero reference level of potential energy at infinite distance from earth.
- Due to smaller value of g on moon, a man can jump **higher** than on earth.
- Due to smaller value of g a man can't run faster on moon.

Do you know?

The gravitational force holds inverse square relationship with the distance of the object from the center of earth.

- ***Escape Velocity***

*The **minimum** initial velocity required by an object on earth to escape from earth's gravitational field.*

$$V_{esc} = \sqrt{2GM_e/R_e} = \sqrt{2g_eR_e}$$

Value of V_{esc} $= 11.2 \times 10^3 \text{m/s} = 6.96 \text{miles/s} = \mathbf{11.2 km/s}$

$= 25000 \text{ miles/h} = 40320 \text{km/h}$

Escape velocity is independent of the mass of the body.

INTER CONVERSION OF K.E AND P.E.

- *In absence of air, friction we get*

$$mgh = \tfrac{1}{2}mV^2$$
$$V = \sqrt{2gh}$$

- If a body is dropped from height 'h' to earth's surface in presence of air, then;

Loss in P.E = gain in K.E + work done against air.

- If a body is thrown vertically upward in gravitational field in the presence of air, then;

Loss in K.E = gain in P.E + work done against air.

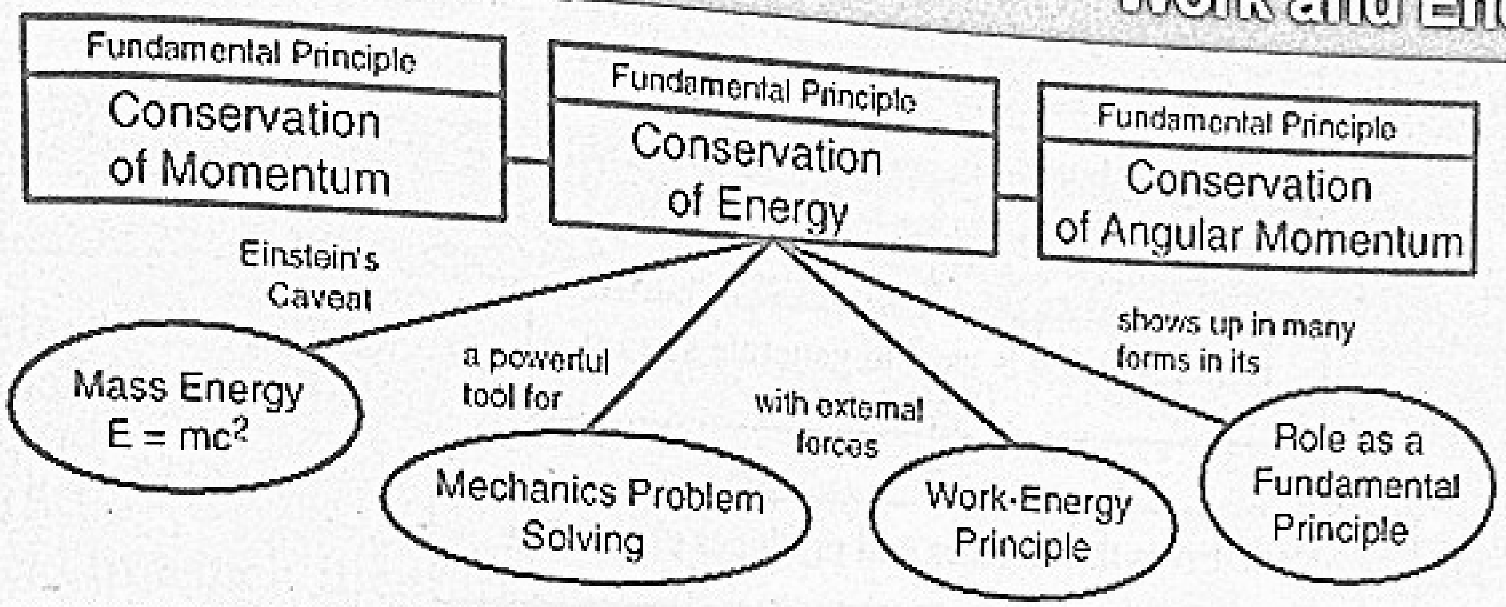
In the absence of air

increase in K.E = decrease in P.E.

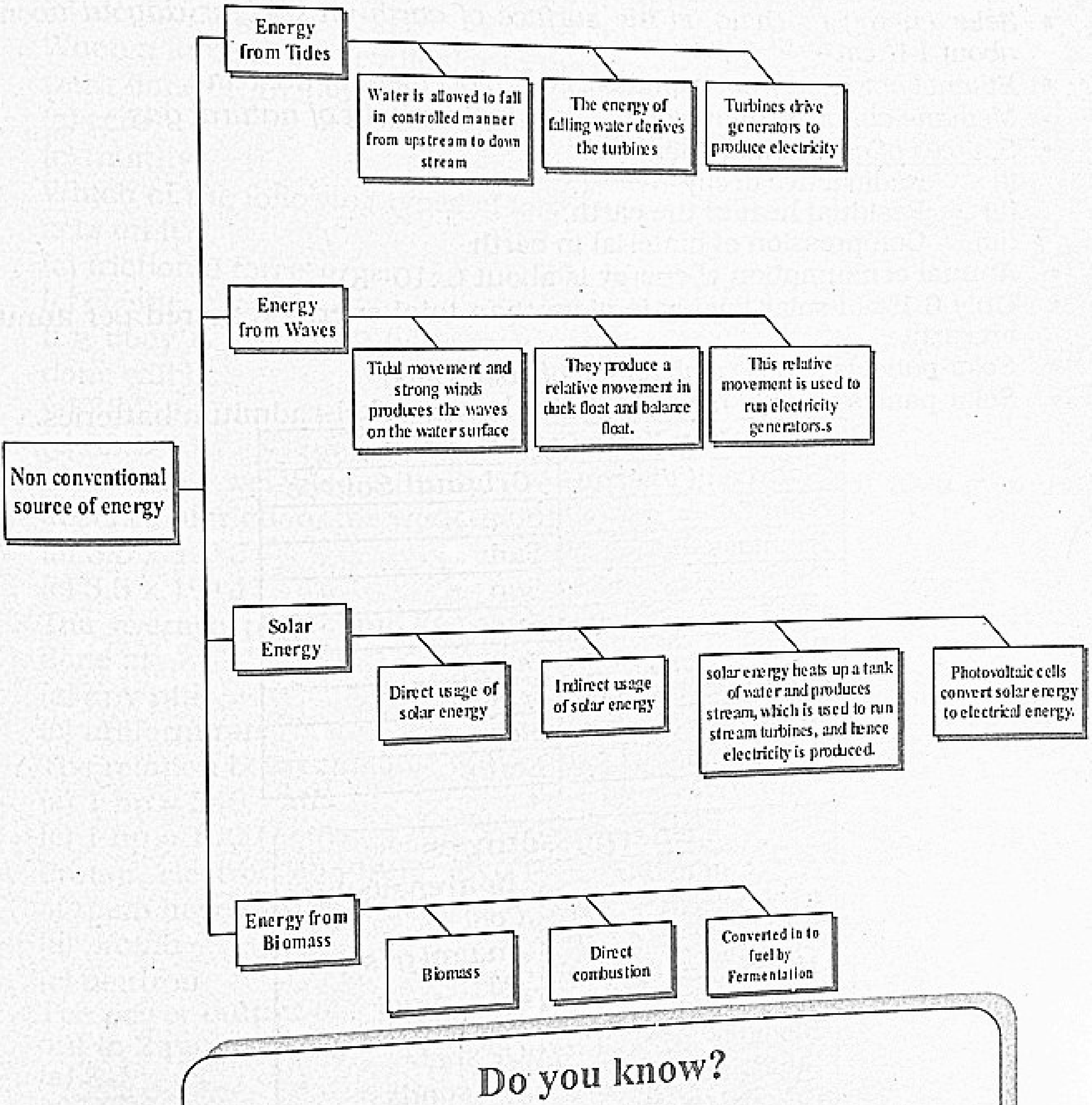
CONSERVATION OF ENERGY

Energy cannot be destroyed. It can be transformed from one kind into another, but total amount of energy remain constant.

When a cup is dropped the P.E changes to K.E, but on striking the ground, the K.E changes to heat and sound but total at each instance is always **conserved.**



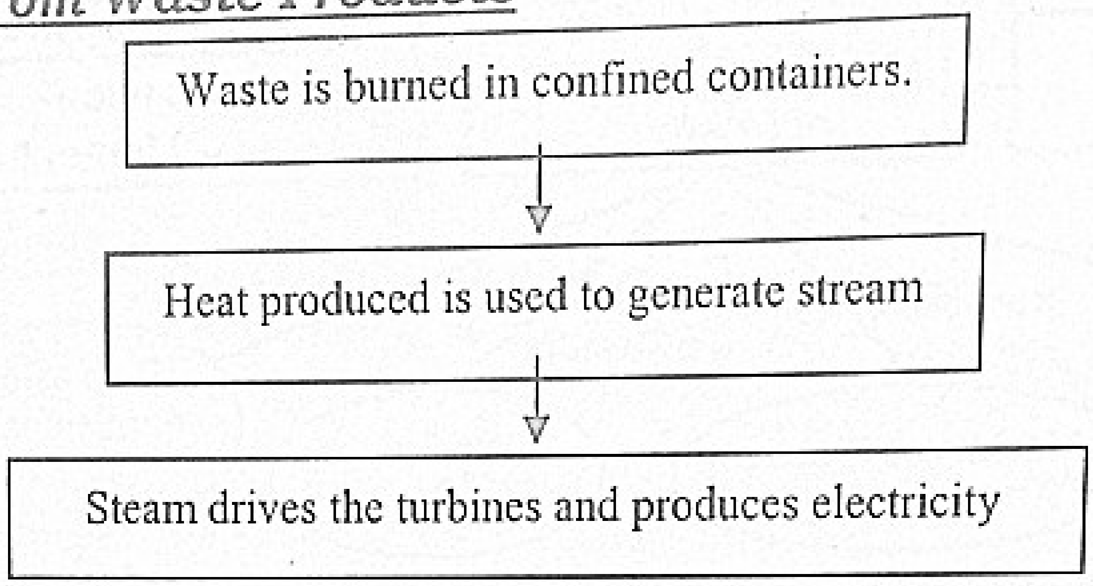
NON-CONVENTIONAL SOURCES OF ENERGY


Non conventional source of energy
Energy from Tides
Water is allowed to fall in controlled manner from upstream to down stream
The energy of falling water derives the turbines
Turbines drive generators to produce electricity
Energy from Waves
Tidal movement and strong winds produces the waves on the water surface
They produce a relative movement in duck float and balance float.
This relative movement is used to run electricity generators.s
Solar Energy
Direct usage of solar energy
Indirect usage of solar energy
solar energy heats up a tank of water and produces stream, which is used to run stream turbines, and hence electricity is produced.
Photovoltaic cells convert solar energy to electrical energy.
Energy from Biomass
Biomass
Direct combustion
Converted in to fuel by Fermentation

Do you know?

The tides raise the water in the sea roughly twice a day.

Energy from Waste Products


Waste is burned in confined containers.
Heat produced is used to generate stream
Steam drives the turbines and produces electricity

- Normal incidence of solar energy outside the earth's atmosphere is about 1.4 Kwm^{-2}
- *Solar energy reaching on the surface of earth on a clear day at noon is about 1 Kwm^{-2}*
- *Ethanol obtained from biomass is a replacement of gasoline.*
- *Methane obtained from biomass is a replacement of natural gas.*
- *Sources of geothermal energy*
  - (i) Radioactive decay
  - (ii) Residual heat of the earth
  - (iii) Compression of material in earth
- Annual consumption of energy is about 6×10^{13}KW
- Only 0.1% of solar energy is more than total energy required per annum on earth
- *Solar panel is series combination of solar cells.*
- Solar panels usually have ability to charge nickel-cadmium batteries.

For Your Information

Source of energy	*Original Source*
Solar	*Sun*
Bio mass	*Sun*
Fossil fuels	*Sun*
Wind	*Sun*
Waves	*Sun*
Hydro electric	*Sun*
Tides	*Moon*
Geothermal	*Earth*

Energy Sources

Renewable	*Nonrenewable*
Hydroelectric	*Coal*
Wind	*Natural gas*
Tides	*Oil*
*Geothermal**	*Uranium*
Biomass	*Oil shale*
Sunlight	*Tar sands*
*Ethanol/Methanol***	

** Individual fields may run off*
*** Renewable when made from bio mass*

Chapter 4

Work and Energy

PRACTICE EXERCISE

30 mins Time Yourself

(1) Work done will be maximum if the angle between the force F and displacement d is
(a) 45°
(b) 90°
(c) 180°
[✓ (d) 0°]

(2) A field in which the work done in a moving a body in a closed path is zero is called
(a) electric field
[✓ (b) conservative field]
(c) electromagnetic field
(d) gravitational field

(3) When a force is perpendicular to the direction of motion of the body, then work done on the body is
[✓ (a) zero]
(b) minimum
(c) infinity
(d) maximum

(4) Which of the following types of force does no work on the particle when it acts on it?
(a) frictional force
(b) gravitational force
(c) elastic force
[✓ (d) centripetal force]

(5) If a body a mass of 2 kg is raised vertically through 2m, then the work done will be
(a) 38.2 J
(b) 392.1 J
[✓ (c) 39.2J]
(d) 3.92J

(6) An elevator weighing $3.5 \times 10^{+6}$ N is raised to a height of 1000 m in the absence of friction, the work done is
(a) 3.5×10^{3} J
(b) 3.5×10^{4} J
(c) 3.5×10^{6} J
[✓ (d) 3.5×10^{9} J]

(7) The average power and instantaneous power become equal if work is done at
(a) any rate
(b) variable rate
[✓ (c) uniform rate]
(d) high rate

(8) The relation between horse power and watt is
(a) 1 hp = 546 watts
[✓ (b) 1 hp = 746 watts]
(c) 1 hp = 1000 watts
(d) 1 hp = 946 watts

(9) Proton, electron, neutron and α particles have same momentum. Which of them have highest K.E?
(a) proton
[✓ (b) electron]
(c) neutron
(d) α-particle

(10) The power output of a lamp is 6W. how much energy does the lamp give out in 2 minutes
(a) 3 J
(b) 120J
[✓ (c) 720J]
(d) 430J

(11) Work done by variable force is determine by dividing
(a) force into small interval
[✓ (b) displacement into small interval]
(c) both force and displacement into small intervals
(d) force into small and displacement into large intervals

(12) Work done on the body equals to the
(a) change in its K.E always
(b) change in its P.E always
(c) change in its K.E or change in its P.E
(d) neither change in K.E nor change in its P.E

(13) The escape velocity of a body in gravitational field of earth is independent of
(a) its mass
(b) the angle at which it is thrown
(c) both its mass and the angle at which it is thrown
(d) gravitational field of earth

(14) The tides raise the water in the sea roughly in a day
(a) once
[✓ (b) twice]
(c) four time
(d) eight time

(15) The source of geothermal energy is
(a) decay of radioactive element in the earth
(b) compression of material in the earth
(c) residual lost of the earth
(d) all as said in a, b and c

(16) The highest value of escape velocity in solar system is for planet
(a) Earth
(b) Neptune
(c) Jupiter
(d) Moon

(17) Work done by the force of friction is
(a) always positive
(b) always negative
(c) positive only for small frictional force
(d) positive only for large frictional force

(18) Gravitational P.E of a body has
(a) no formula
[✓ (b) mgh]
(c) $q \Delta V$
(d) $\frac{1}{2}kx^2$

(19) If velocity is doubled, then
(a) momentum increases 4 times and K.E increases 2 times
(b) momentum and K.E. remain same
(c) momentum increases 2 times and K.E increases constant
(d) momentum increases 2 times and K.E increases 4 times

(20) We get energy from food during a day which is equivalent to the energy obtained from ________ liter petrol.
(a) 1
(b) $\frac{1}{2}$
(c) $\frac{1}{3}$
(d) $\frac{1}{4}$

(21) One mega watt hour is equal to
(a) 36×10^{6} J
(b) 36×10^{12} J
(c) 36×10^{9} J
(d) 36×10^{8} J

(22) Which of the following is not conservative force
(a) friction (b) electric
(c) gravitational (d) elastic

(23) Work has the dimension as that of same as that of
(a) torque (b) angular momentum
(c) linear momentum (d) power

(24) The consumption of energy by a 60 watt bulb in 2 sec is
(a) 120 J (b) 60J
(c) 30J (d) 0.02J

(25) The relation between the escape velocity V_{esc} and orbital speed V_o is given by
(a) $V_{esc} = 1/2V_o$ (b) $V_{esc} = \sqrt{2}\,V_o$
(c) $V_{esc} = V_o$ (d) $V_{esc} = 2V_o$

(26) The escape velocity form the earth surface in km s^{-1} is about
(a) 4.2 km $s^{-(a)}$ (b) 7.5 km s^{-1}
(c) 9.5 km s^{-1} (d) 11km s^{-1}

(27) If moon radius is 1600 km and g on its surface is 1.6 ms^{-2}, then the escape velocity on the moon is
(a) 1600 ms^{-1} (b) 50.6ms^{-1}
(c) 71.6ms^{-1} (d) 2240ms^{-1}

(28) When two protons are brought close, their
(a) Kinetic energy increases (b) P.E. increases
(c) P.E. decreases (d) P.E. doe not change

(29) When arrow is released form its bow, its energy is transformed from
(a) heat energy to K.E (b) elastic P.E to K.E
(c) chemical energy to elastic P.E (d) K.E to elastic P.E.

(30) Two bodies of 4g and 16g have the same K.E. What is the ratio of their momentum
(a) 2:1 (b) 4:1
(c) 1:2 (d) 1:4

(31) Escape velocity depends upon the radius of earth which shows its proper dependence
(a) $V \alpha R$ (b) $V \alpha R^{-\frac{1}{2}}$
(c) $V \alpha R^{\frac{1}{2}}$ (d) $V \alpha R^{-1}$

(32) The area under the force displacement graph represents
(a) area (b) work done
(c) power (d) none of these

(33) A tennis ball is dropped on to a horizontal surface. As the ball bounces up and down, the height of each bounce gradually decreases, during the motion of the ball
(a) the K.E of the ball is constant
(b) The sum of P.E and K.E energies of the ball is constant
(c) The P.E of the ball is constant
(d) The total energy of the ball, ground and air is constant

(34) Propulsion force of a rocket is
(a) non-conservative force (b) conservative force
(c) both (a) and (b) (d) none of these

(35) A car is driven along a level road. The total energy input from the petrol is 60kJ an d the car wastes 45kJ of energy, what is the efficiency of car
(a) 25% (b) 15%
(c) 45% (d) 75%

(36) Geothermal energy is a ______________ source of energy.
(a) non-renewable (b) stable
(c) renewable (d) none of the above

(37) The source of tidal energy is
(a) sun (b) earth
(c) both (a) and (b) (d) moon

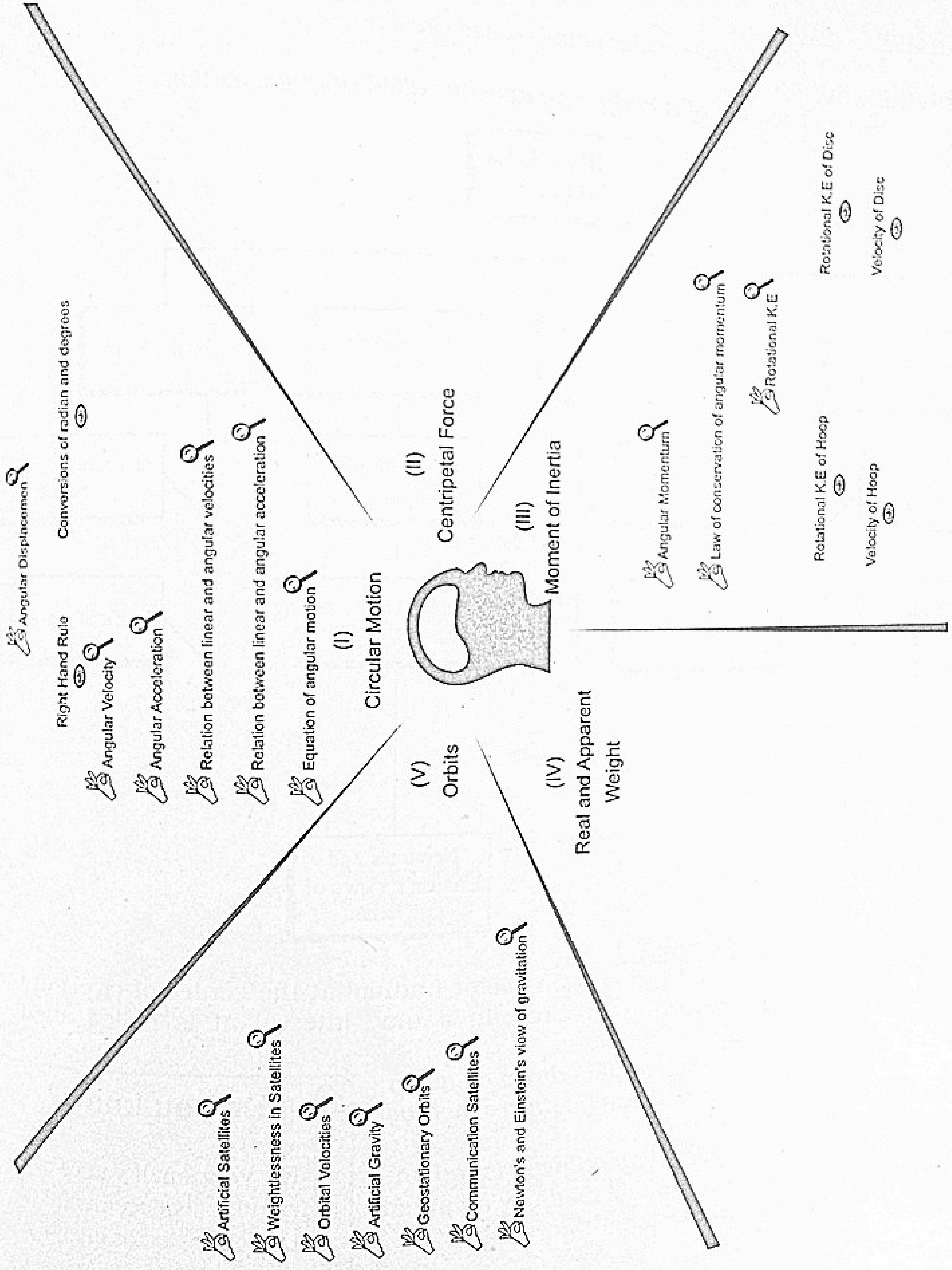
(38) ______________ cells converts solar energy into electrical energy
(a) rotory (b) photovoltaic
(c) galvanic (d) none of these

(39) From which source would the release of energy b affected by the change in the earth's gravitational field
(a) Geothermal (b) Chemical
(c) Hydroelectric (d) nuclear

(40) The center of sun produces large amounts of energy, what s the source of this energy
(a) Chemical reaction (b) Nuclear fission
(c) Nuclear fusion (d) Radioactive decay

Chapter 5

CIRCULAR MOTION



Chapter 5

Circular Motion

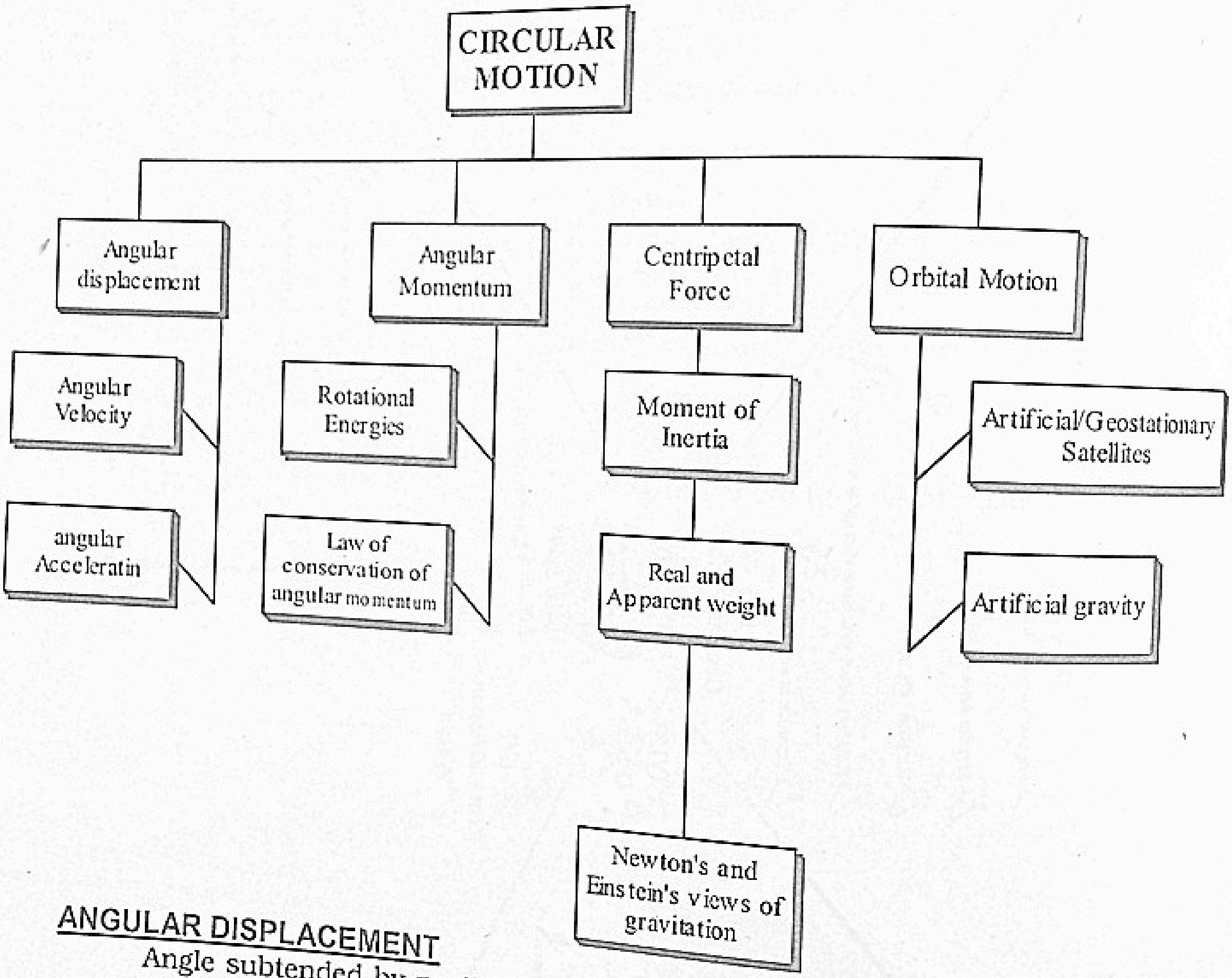
INTRODUCTION

Circular Motion

Motion of bodies in circular path is called circular motion

Angular Motion

Circular motion of a body may also be called angular motion.



ANGULAR DISPLACEMENT

Angle subtended by position vector (radius) at the center of circle of the body while revolving in circle in a time interval Δt is called angular displacement

- *Angular displacement has direction along axis of rotation and can be determined by right hand rule*
- *SI unit of angular displacement is radian*
- *One radian* is an angle made by an arc at the center, whose length is equal to the radius of circle.

Do you know?

For very small values of angular displacement it is treated as vector quantity.

TOP Study

- Definition of radian gives following useful relation:

$$S = r\theta$$

$$1^\circ = \pi/180 \text{ rad} = 0.0174 \text{ rad}, \qquad 1 \text{ rad} = 57.3^\circ$$

- Angular displacement is angle in radian or degree covered by body having circular motion.

ANGULAR VELOCITY & ACCELERATION

- *Rate of change of angular displacement is called angular velocity:*

$$\vec{\omega} = \Delta\theta/\Delta t$$

- Angular velocity is a vector quantity.

$$\vec{V} = \vec{\omega} \times \vec{r}$$

- *SI unit of angular velocity is rad/sec.*
- *Rate of change of angular velocity is called angular acceleration.*

$$\vec{\alpha} = \Delta\vec{\omega}/\Delta t$$

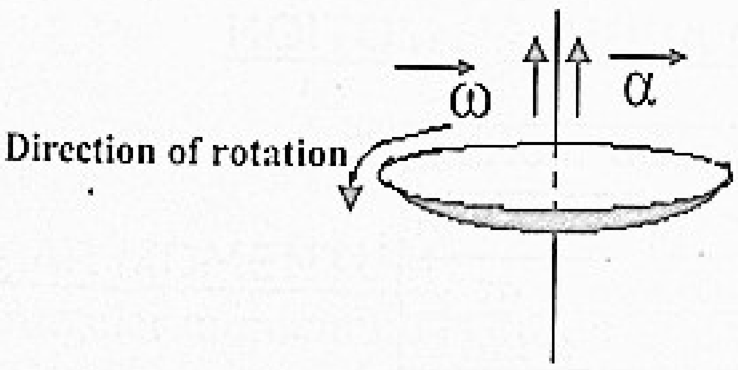
- *SI unit of angular acceleration is rad/sec^2.*
- Angular acceleration is a vector quantity.

$$\vec{a} = \vec{\alpha} \times \vec{r}$$

Do you know?

The angular velocity is practically measured in revolution per minute (rpm) as they provide an easy interpretation of angular motion.

- *Direction of angular acceleration is along axis of rotation and is determined by right hand rule.*



Do you know?

All the points on a rigid body rotating about a fixed axis have same angular displacement, velocity and acceleration.

- *If angular velocity increases, then $\vec{\omega}$ and $\vec{\alpha}$ are in same direction and if angular velocity decrease, then $\vec{\omega}$ and $\vec{\alpha}$ are in opposite direction*

RIGID BODY

"A body, which maintains a constant distance between its two consecutive particles, when a definite load is applied to it."

*Note that all the solid bodies can be treated as rigid in **a specific range of loads** only.*

e.g. wall is treated to be rigid for a human being but not for hammer.

CENTRIPETAL ACCELERATION & FORCE

The force required to bend a straight line path of a body into the circular path is called centripetal force.

If the centripetal force is removed from the rotating object it will follow a straight-line motion confined on the tangent to that circular path.

ASSUMPTIONS

To derive the equations for the centripetal acceleration we assume that speed of the object is constant so that the tangential component of velocity does not produce acceleration but normal component only. The equation is

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}\hat{a}_t + \frac{v^2}{r}\hat{a}_n$$

- In vector form, centripetal force and acceleration can be written as;

$$\vec{F_c} = - m r \omega^2 r\hat{} = - m \vec{r} \omega = - (mV^2/r) r\hat{} = - (mV^2/r^2) \vec{r}$$

$$\overrightarrow{a_c} = - r \omega^2 r\hat{} = - \vec{r} \omega = - (V^2/r) r\hat{} = - (V^2/r^2) \vec{r}$$

- *Reaction of centripetal force is called centrifugal force.*

  $$\overrightarrow{F_f} = -\overrightarrow{F_c}$$

- *Work done by centripetal force is zero.*
- Centripetal and centrifugal forces form true action & reaction pair but they can't balance each other because they don't act on same body.

Point to Ponder

We can walk on the walls and roofs of the house if the house is

COMPARISON OF LINEAR MOTION AND ANGULAR MOTION

Linear motion	*Angular motion*
$S = Vt$	$\theta = \omega t$
$V_f = V_i + at$	$\omega_f = \omega_i + \alpha t$
$S = V_f^2 + 1/2at^2$	$\theta = \omega_f^2 + 1/2\alpha t^2$
$2aS = V_f^2 - V_i^2$	$2\alpha\theta = \omega f^2 - \omega_i^2$
$F = ma$	$T = I\alpha$
$<V> = V_f + V_i/2$	$<\omega> = (\omega_f + \omega_i)/2$
$p = mV$	$L = I\omega$

MOMENT OF INERTIA

"The measure of hindrance offered by a rigid body against angular motion, when a disturbing torque acts over the body."

Mathematically expressed as moment of inertia $= I = (m)(r^2)$.

It can also be defined as "second moment of mass." as

$$I = (m \times r) \times r$$

Second moment

measured in kgm². Moment of inertia depends upon

(i) Mass of the body.

(ii) Distribution of the mass about the axis of rotation.

- *Moment of inertia plays same role in angular motion as the mass in linear motion.*

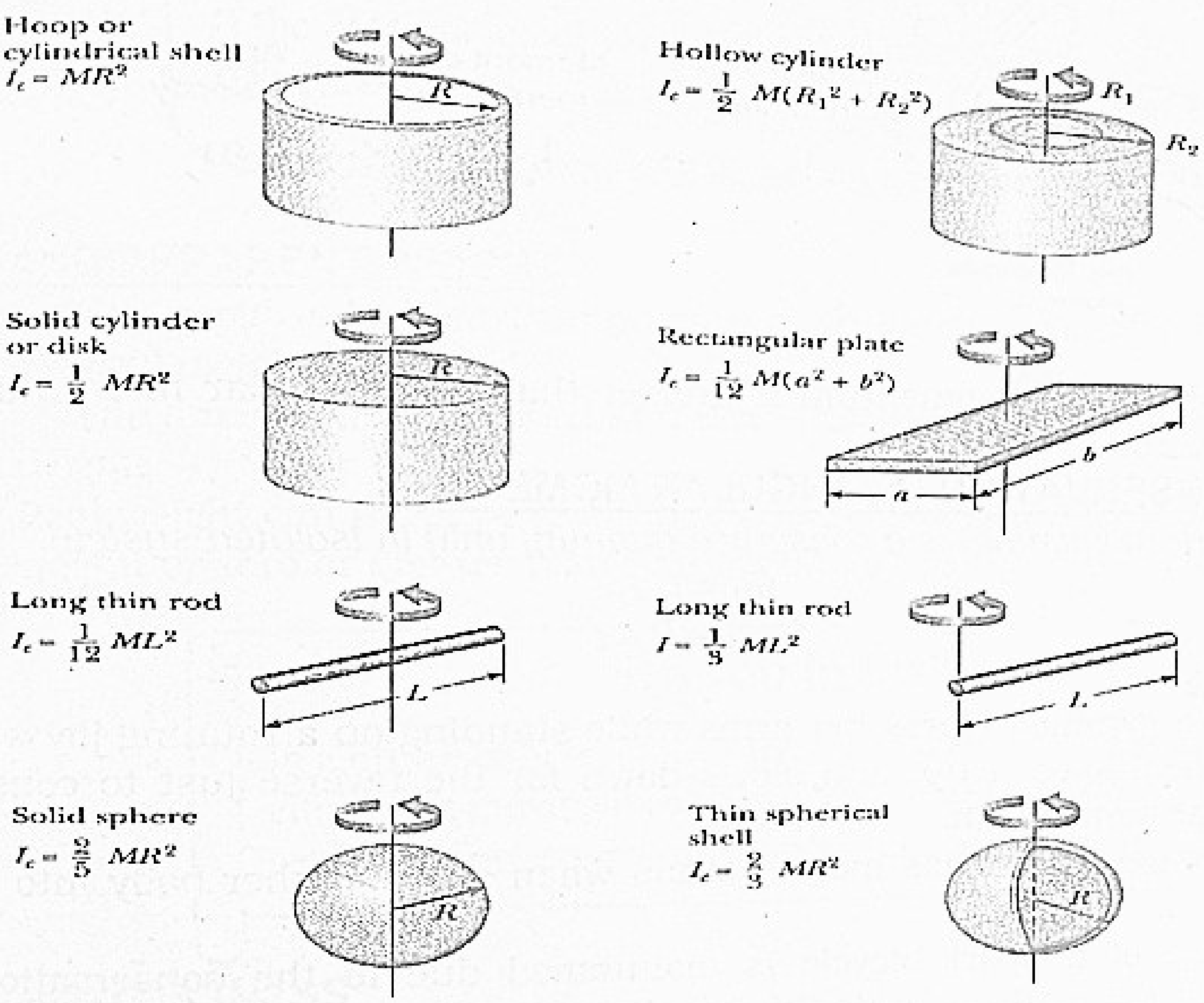
The equation

$\tau = I\alpha$

is the rotational analogue of the Newton's second law

$F = ma$

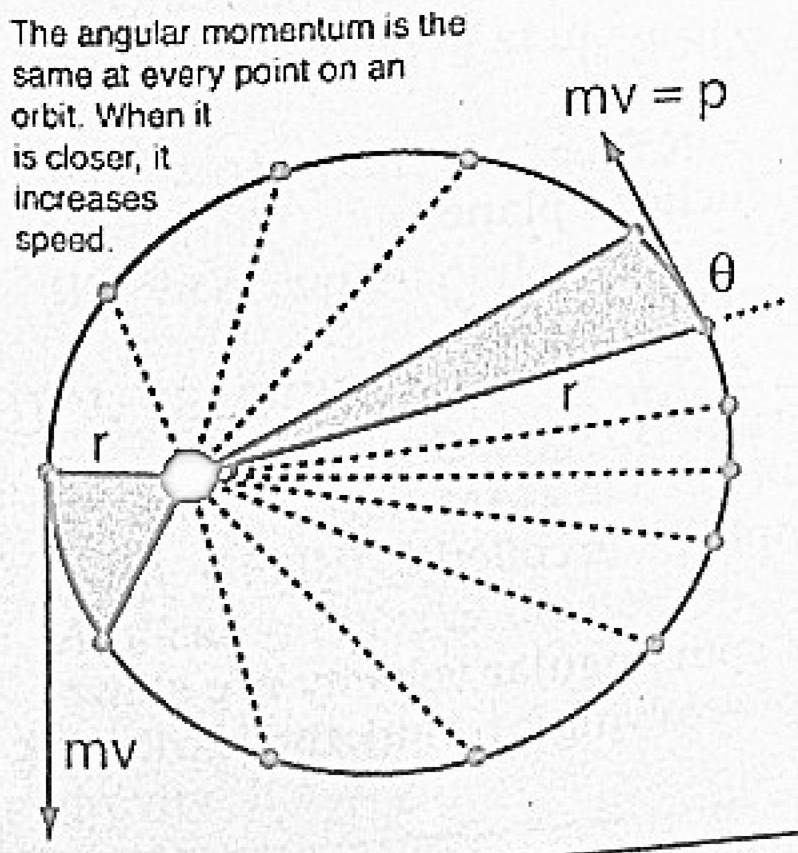
Moment of Inertia of Some Regular Bodies



ANGULAR MOMENTUM

- Angular momentum is due to spin motion or angular motion of a body.

Angular Momentum of a Particle


The angular momentum is the same at every point on an orbit. When it is closer, it increases speed.
mv = p
θ
r
r
mv

The angular momentum of a particle of mass m with respect to a chosen origin is given by

$$L = mvr\sin\theta$$

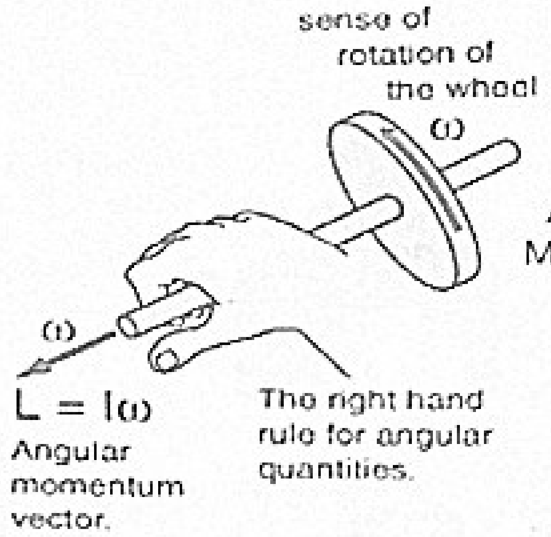
or more formally by the vector product

$$\mathbf{L} = \mathbf{r} \times \mathbf{p}$$

The direction is given by the right hand rule which would give L the direction out of the diagram. For a circular orbit, L becomes $L = mvr$

Angular Momentum

The angular momentum of a rigid object is defined as the product of the moment of inertia and the angular velocity.


sense of rotation of the wheel
ω
ω
L = Iω
Angular momentum vector
The right hand rule for angular quantities.

Angular Momentum = Moment of Inertia × Angular Velocity

$$L = I \times \omega$$

- Orbital angular momentum is greater than spin angular momentum of an electron.

LAW OF CONSERVATION OF ANGULAR MOMENTUM

Angular momentum is a conserved quantity only in isolated system.

$$L_1 = L_2$$

$$I_1\,\omega_1 = I_2\,\omega_2$$

Applications

- When a gymnast closes her arms while standing on a rotating joy wheel, the wheel speeds up, and slows down for the reverse just to conserve angular momentum.
- Springboard diver has more rotation when she pulls her body into tuck position.
- Balance of a sport bicycle is maintained due to the conservation of angular momentum for its thin rotating wheels.
- Angular momentum is conserved if external torque is zero.

ROTATIONAL K.E

- Rotational K.E is given by

$$K.E_{rot} = \tfrac{1}{2} I\,\omega^2$$

- Rotational K.E of disc

$$K.E_{rot} = \tfrac{1}{4} mV^2 = \tfrac{1}{2}(K.E_{lin})$$

- Rotational K.E of hoop

$$K.E_{rot} = \tfrac{1}{2} mV^2 = (K.E_{lin})$$

- Velocity of hoop at the bottom of an inclined plane

$$V = \sqrt{gh}$$

- Velocity of disc at the bottom of an inclined plane

$$V = \sqrt{\frac{4}{3} gh} = \frac{2}{\sqrt{3}}\sqrt{gh}$$

ARTIFICIAL SATELLITES

An object revolving around a star or planet is called satellite

- Moon is natural satellite of earth
- Moon's orbital angular velocity and spin angular velocity are same
- A man made rocket or space ship revolving around the earth is called *artificial satellite.*

- Artificial satellite revolves around the earth due to force of gravity.
- Critical velocity of an artificial satellite is $V = \sqrt{gR} = 7.9\ \text{Km S}^{-1}$
- Period of such artificial satellite is 5060s or 84 min.

Do you know?

If the acceleration of satellite close to earth is not 9.8m/sec^2 then it will fly off tangent to the earth.

REAL AND APPARENT WEIGHT

Force with which earth attracts a body towards its center is equal to the real weight of the body.

The force required to prevent a body from free fall is called its apparent weight.

- Real weight can never be zero while apparent weight may be equal to real weight or zero or greater than real weight or less than real weight.

Do you know?

In a lift we only feel the difference in weights when the lift either start moving up or down, once constant velocity is achieved then weight variation become zero as well.

WEIGHGTLESSNESS

Weightlessness is a state with absence of restraining force and disappearance of gravity.

- To observe weightlessness, the frame of reference of observer must be the same as that of satellite or should move like parallel to its fall. e.g. *weightlessness is observed only by observer inside the lift not outside it.*
- *Weight occupant of stationary or constantly moving lift is;*

$$w' = mg$$

- *Weight occupant of ascending satellite is;*

$$w' = (g + a)m$$

- *Weight occupant of descending satellite is;*

$$w' = (g - a)\ m$$

ORBITAL VELOCITY

Orbital velocity for a satellite is $V = \sqrt{MG/r}$

This shows that mass of satellite is not important in describing its orbit.

ARTIFICIAL GRAVITY

- *Artificial gravity is created by setting satellite into rotation about its own axis.*
- Artificial gravity is a reactional force, which gives impression of real gravity. If $a_c = g$.

- Frequency of rotation to produce artificial gravity, in a spaceship is;

  $f = 1/2\pi\sqrt{g/R}$
- Time period of rotation to produce artificial gravity, equal of real gravity is;

  $T = 2\pi\sqrt{R/g}$

GEO-STATIONARY & COMMUNICATION SATELLITES

A satellite whose position does not change w.r.t a certain point on earth is called geo-stationary satellite.

- Its orbital motion is synchronized with the rotation of earth.
- *Geo-stationary satellite completes one rotation in* ***24 hours.***
- Three geo-stationary satellites placed at 120° intervals about the equator can effectively cover the whole globe for communication.
- Radius of geo-stationary orbit is given by

$$r = \left(\frac{GMT^2}{4\pi^2}\right)^{1/3}$$

Its value is 4.23×10^4km from center of earth at **equator.**

- *Height of geo-stationary satellite above the equator is* ***36000km.***
- The largest satellite communication system is managed by 126 countries and named as International Telecommunication Satellite Organization ***(INTELSAT).***

NEWTON'S & EINSTEIN'S VIEWS OF GRAVITATION

- According to Newton, gravitational interaction is taking place between material objects and is directly proportional to the product of the masses

Quantity	Translation	Rotational	relation
Displacement	D	θ	$s = r\theta$
velocity	$v = \frac{d}{t}$	$\omega = \frac{\Delta\theta}{\Delta t}$	$v = r\omega$
Acceleration	$a = \frac{\Delta v}{\Delta t}$	$\alpha = \frac{\Delta\omega}{\Delta t}$	$a_T = r\alpha$ $a_r = r\omega^2$
Mass/moment of Inertia	m	$I = mr^2$	$I = \sum mr^2$
Force / Torque	F = ma	$\tau = r \times F$	
Kinetic Energy	K.E = 1/2 mv^2	$K.E_{rot} = 1/2 I\omega^2$	
Momentum	p = mv	$L = I\omega$	L = r x p
Power	P = Fv	$P = \tau\omega$	
Work	W = F . d	$W = \tau . \Delta\theta$	
Impulse	$I = F\times\Delta t$	$I = \tau\Delta t$	
Equilibrium	$\sum F = 0$	$\sum \tau = 0$	

of the objects and inversely proportional to the square of the distance between their centre.

- According to Einstein, gravitational interaction is taking place between material objects and also between material object and electromagnetic radiation.
- According to Einstein, gravity follows the inverse square law, but when gravitational fields are very strong inverse square law not holds.
- *Einstein's theory is more close to the experimental facts than that of Newton's theory.*

Do you know?

If the gravity and acceleration of light are precisely equal then gravity must bend light as measured in solar eclipse in 1919.

$= \boxed{2\pi\,rad}$

PRACTICE EXERCISE

30 mins Time Yourself

(1) The rotational K.E of hoop is equal to the
(a) its translational K.E
(b) half than its translational K.E
(c) double than its translational K.E
(d) four times than its translational K.E

(2) A hoop and disc have same mass and radius. Their rotational K.E are related by an equation
(a) $K.E_{hoop} = K.E_{disc}$ (b) $K.E_{hoop} = 2K.E_{disc}$
(c) $K.E_{hoop} = 1/2K.E_{disc}$ (d) $K.E_{hoop} = 4K.E_{disc}$

(3) The angular velocity of the minute hand of a clock is
(a) $\frac{2\pi}{60} rads^{-1}$ (b) $\frac{\pi}{24} rads^{-1}$
(c) $\frac{2\pi}{3600} rads^{-1}$ (d) $\frac{\pi}{3600} rads^{-1}$

T = 3600
θ = 2π

(4) The angular K.E of a body is independent of
(a) speed (b) moment of inertia
(c) angular momentum (d) none of these

(5) A boy suddenly comes and sit on the circular rotating table. What will remain conserved
(a)angular momentum (b)linear velocity
(c)kinetic energy (d)none of these

(6) According to Einstein, the gravity interaction is possible between
(a)material objects only
(b)material objects and electromagnetic radiation only
(c)electromagnetic radiations
(d)none of the above

(7) The number of revolutions in 3π radians
(a) 2/(c) (b) 3/2
(c) 6 (d) 1/60

2π = 1
1π = 1/2 rev
3π = 1/2 × 3 rev

(8) The period of a circular motion is given by
(a) T = rV (b) T = ωw
(c) T = 2πω (d) T = 2π/ω

1 day = 24×
= 24
= 3

(9) The direction of linear velocity of body moving in a circle is
(a) along the axis of rotation (b) along the tangent
(c) directed towards the center (d) directed away form the center

(10) When a body moves in a circle, the angle between its linear velocity and angular velocity is always
(a)180° (b) 0°
(c) 90° (d) 45°

θ, ω, α, L along axis of rotation

(11) An arc of length equal to the circumference of circle subtends an angle
(a)π radian (b) 2π radian
(c) π/2 radian (d) 4π radian

(12) The relation between linear and angular acceleration is
(a) $\vec{\alpha} = \vec{a} \times \vec{r}$
(b) a = r x α
(c) $\vec{a} = \vec{\alpha} \times \vec{r}$
(d) r = α x a

(13) When a body is whirled in a horizontal circle by means of a string the (a) centripetal force is supplied by
(a) mass of a body
(b) velocity of body
(c) tension in the string
(d) centripetal acceleration

(14) What remain constant when the earth revolve around the sun
(a) Linear momentum
(b) Linear K.E
(c) Angular K.E
(d) Angular momentum

(15) The angular momentum of a body is conserved if
(a) Force acting on it constant
(b) Force acting on it is zero
(c) Torque acting on it zero
(d) All of these

(16) A stone is whirled in a vertical circle at the end of a string. When the stone is at the highest position the tension in the string is
(a) maximum
(b) zero
(c) equal to the weight of the stone
(d) less than the weight of the stone

(17) The span of broad jump depends upon
(a) mass of the jumper
(b) height of jump
(c) angle of projection
(d) none

(18) In case of planets the necessary acceleration is provided by
(a) Gravitational force
(b) frictional force
(c) coulomb force
(d) centripetal force

(19) If a car moves with a uniform speed of 2 ms^{-1} in a circle of radius 0.4. Its angular speed is
(a) 4 rad. s^{-1}
(b) 5 rad. s^{-1}
(c) 1.6 rad. s^{-1}
(d) 2.8 ms^{-1}

$V = 2$ $r = 0.4$
$\omega = ?$ $v = r\omega$
$\omega = \frac{V}{r} = \frac{2}{0.4}$
$\frac{20}{4}$

(20) A body can have constant velocity when it follows a
(a) elliptical path
(b) circular path
(c) parabolic path
(d) rectilinear path

(21) A body moving along the circumference of a circle, completes two revolutions if the radius of the circular path is R, total angular displacement covered is
(a) π R
(b) 2πR
(c) zero
(d) 4πR

$2 rev = \theta$
$r = R$
$S = r\theta$
$\theta = \frac{S}{r} = \frac{4\pi}{R}$

1 day = 24x60x60
= 24x3600
= 36400 s

(22) The angular speed for daily rotation of earth in rad s^{-1} is
(a) 2 π
(b) π
(c) 4π
(d) 7.3 x 10^{-5} $rads^{-1}$

$\omega = \theta/T$ $\frac{2\pi}{}$

(23) Time taken by geostationary satellite to complete one rotation around earth is
(a) 1 year
(b) 1 day
(c) 1 hour
(d) 84 min

(24) The direction of angular momentum is along
(a) Tangent to the circle
(b) Inward the radius
(c) Axis of rotation
(d) Outward of the radius

(25) If a wheel of radius r turns through an angle of 30°, then the distance through which any point on its rim moves is
(a) π/3 x r
(b) π/6 x r
(c) π/30 x r
(d) π/180 x r

(26) In angular motion, Newton's second law of motion is
(a) F=ma
(b) $F=\Delta p/\Delta t$
(c) $\tau = I\alpha$
(d) all of above

(27) Angular speed of second's hand of a watch in $rads^{-1}$ is
(a) π
(b) $\pi/2$
(c) $\pi/30$
(d) $\pi/180$

$\omega=?$ $t=60s$ $\theta=2\pi$ $\omega=\frac{2\pi}{60s}$

(28) The shaft of a motor rotates at a constant angular speed of 360rev/min. Angle turned through in 1 sec in radian is
(a) π
(b) 3π
(c) 6π
(d) 12π

$\frac{360 rev}{min}$

(29) What is outward force acting on a mass of 10kg when rotating at one end of an inelastic string 10m long at speed of 1m/s?
(a) 1N
(b) 10N
(c) 2N
(d) 100N

r=10m m=10kg v=1m/s
F=? $F=\frac{mv^2}{r}$

(30) If we whirl a stone at the end of a string in the vertical circle, it is likely to break when the stone is
(a) at the highest point
(b) at the lowest point
(c) at any point during motion
(d) at the point where gravity is not acting

(31) A body moving along the circumference of a circle completes two revolutions. If the radius of the circular path is R, the linear displacement covered by body is
(a) R
(b) 2R
(c) zero
(d) 4R

(32) A man of weight W is standing on an elevator which is ascending with an acceleration a. The apparent weight of the man is
(a) mg
(b) mg – ma
(c) mg + ma
(d) mg – ma

T-W=ma
T=ma+W
=ma+mg

(33) Who discovered the inverse square law for gravity?
(a) Einstein
(b) Galileo
(c) Newton's
(d) Plank

(34) The planet nearest to the earth is
(a) Venus
(b) Mercury
(c) Uranus
(d) Sun

(35) A satellite moving round the earth constitutes
(a) An inertial frame of reference
(b) non inertial frame
(c) neither inertial nor non inertial
(d) both inertial and non inertial

(36) A body of mass 10kg is rotating in a circular path of radius 'r' m with constant speed. The work done in one complete revolution is
(a) 10.3 $rads^{-1}$
(b) zero
(c) 100 $rads^{-1}$
(d) 0.5 $rads^{-1}$

(37) A body of 2kg is suspended form the ceiling of an elevator moving up with an acceleration g. Its apparent weight in the elevator will be
(a) 9.8N
(b) 19.6N
(c) 129.4N
(d) 39.2N

(38) Movement of inertia of which body about its perpendicular axis is greater, all have same mass and radius
(a) sphere
(b) hoop
(c) disc
(d) all have same movement of inertia

(39) How many days would be in a year if the distance between the earth and the sun were reduced to half of its present value (assuming circular orbit)?

(a) 365 days (b) 730 days

(c) 329 days (d) 129 days

$T = \frac{2\pi R}{V} = \frac{\pi}{V}$

(40) When a body is moving along a circular, path, it covers a certain angle in a given internal of time. Such type of motion is

(a) vibratory motion (b) linear motion

(c) rotatory motion (d) angular motion

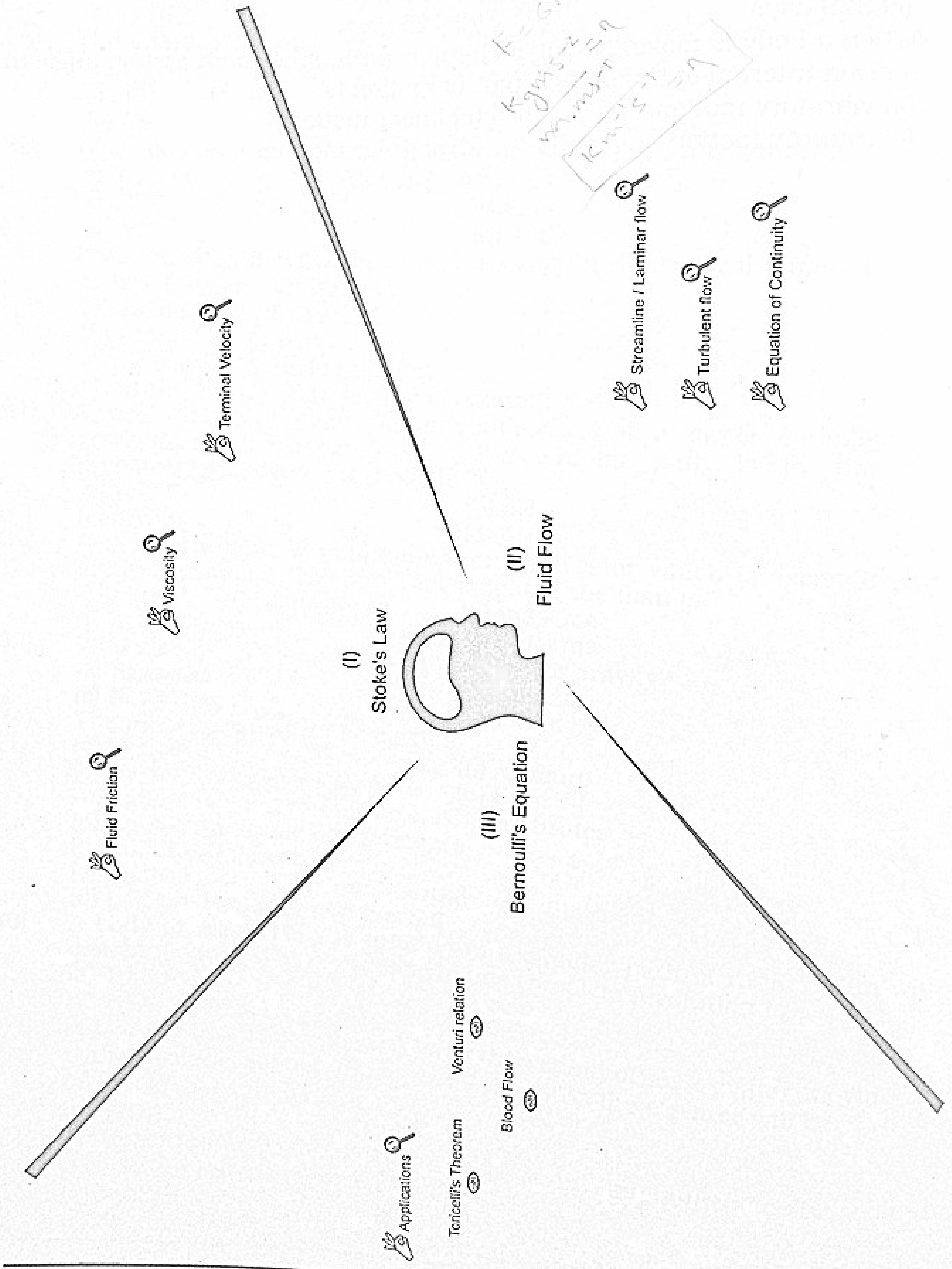
$T = \frac{2\pi R}{V}$ $T' = \frac{2\pi R/2}{V} = \frac{2\pi R}{2} \times \frac{1}{V} = \frac{1}{2}\left(\frac{2\pi R}{V}\right)$

$T' = T/2 = \frac{365}{2}$

182
2)365
2
16
16
1

Chapter 6

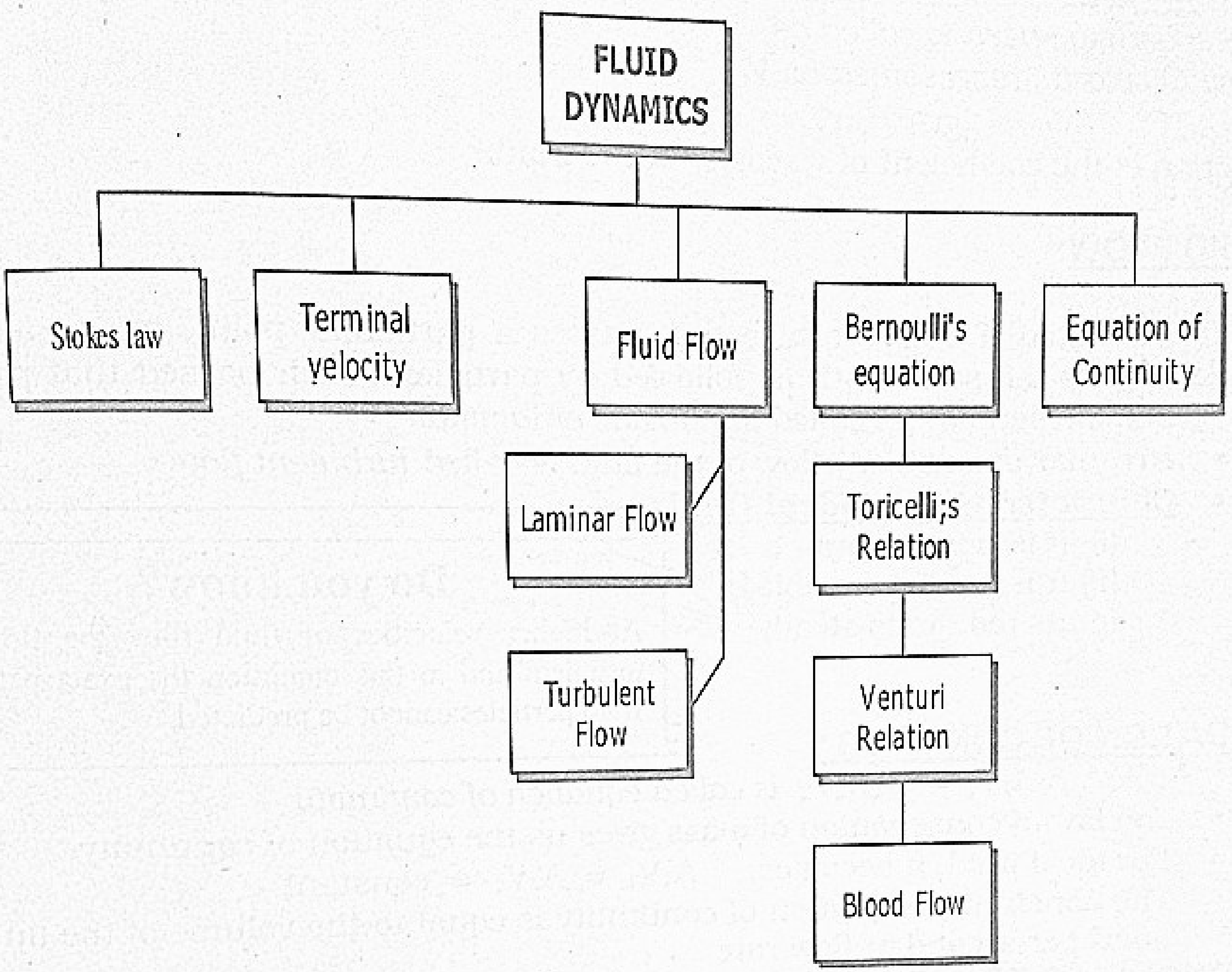
FLUID DYNAMICS



$F = 6\pi\eta rv$

$\frac{kgms^{-2}}{m.ms^{-1}} = \eta$

$\boxed{kgm^{-1}s^{-1} = \eta}$



VISCOUS DRAG AND STOKES LAW

- Viscosity is the measure of the force required to slide one layer of a liquid over another.
- *SI unit of coefficient of viscosity is $Kgm^{-1}s^{-1}$ and dimension $ML^{-1}T^{-1}$*
- Substance that flows easily like water etc has lesser coefficient of viscosity.
- The force experienced by an object while moving in a viscous medium is called drag force.
- The drag force in a medium depends on the profile of the object and velocity of the same object and nature of medium

Mathematically drag force can be related with above stated factors using strokes law $F_D=6\pi\eta rv$.

The strokes law holds well at low speeds only for spherical bodies.

Do you know?

When an object is moving in a fluid at considerably higher speed then the force of drag is no more proportional to the speed.

TERMINAL VELOCITY

When a spherical object falling gains a constant speed in a medium then the net force acting on it is zero and the *corresponding speed is called as terminal velocity represented as* V_t

$$V_t = 2gr^2\rho/9\eta \quad \Rightarrow V_t \propto r^2$$

where η is the coefficient of viscosity of the fluid.

FLUID FLOW

- In a fluid if every particle that passes a particular point, moves along exactly the same path as followed by particles which passed that point earlier then flow is called *streamline or laminar*
- Irregular or unsteady flow of the fluid is called *turbulent flow*
- ***Characteristics of ideal fluid***
  - (i) It is non viscous
  - (ii) It is incompressible
  - (iii)Its motion is steady

Do you know?

At higher velocities of fluid flow the flow is turbulent and in this condition the exact path of fluid particles cannot be predicted.

EQUATION OF CONTINUITY

$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$ *is called equation of continuity*

- The law of conservation of mass gives us the equation of continuity.
- For ideal fluid, it becomes; $A_1V_1 = A_2V_2 = \text{constant}$
- The constant in equation of continuity is equal to the volume of the fluid flows per second or flow rate

BERNOULLI'S EQUATION

Bernoulli's equation is derived from conservation of energy.

- *Bernoulli's equation is* $P + 1/2\, \rho V^2 + \rho g h = \text{constant}$
- Fluid have three types of energies-

(1) Potential energy = mgh or potential energy per unit volume = ρgh
(2) Kinetic energy = $\frac{1}{2}mv^2$ or kinetic energy per unit volume = $\frac{1}{2}\rho V^2$
(3) Pressure energy = PV or pressure energy per unit volume = P

APPLICATIONS

SPEED OF EFFLUX

- Speed of efflux is determined by Torricelli's theorem $V = \sqrt{2g\,(h_1 - h_2)}$
- Speed of efflux depends upon the height through which fluid falls under the action of gravity
- Pressure of fluid increases if the speed of fluid decreases and vice versa.
- An aero plane lifts due to the difference of pressure on its wings
- Swing in cricket and tennis ball is also due to and difference of pressure on its two sides
- There is a danger that a person standing nears a fast moving train to fall towards it.
- Venturimeter is a device used to measure the speed of liquid flow
- Venturimeter works according to venturi relation which is

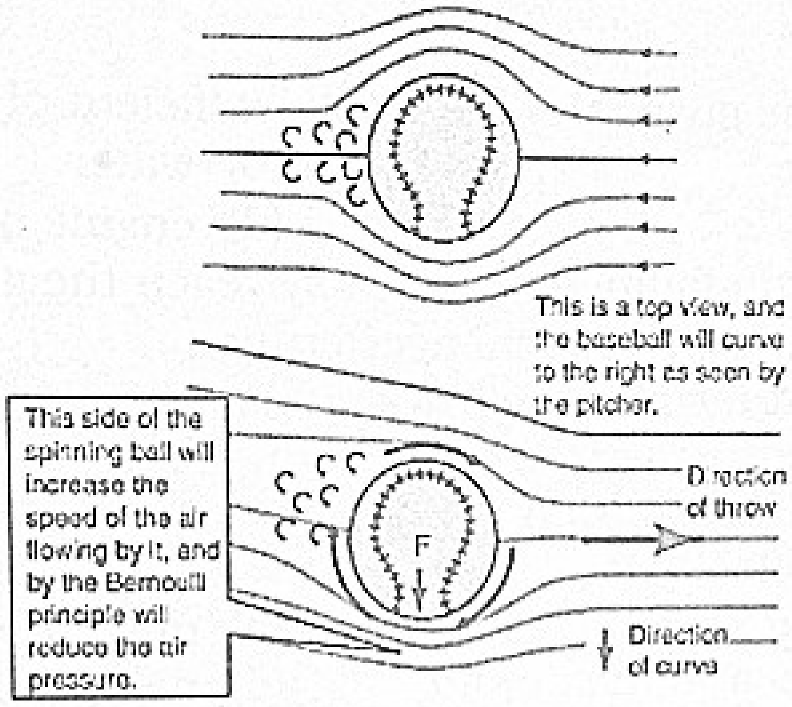
$$P_1 - P_2 = \frac{1}{2}\rho v^2$$

TOP Study

- Mixing of petrol with air in carburetor is according to the Bernoulli`s equation

BLOOD PRESSURE

- instrument used to measure blood pressure is called sphygmomanometer. It measures blood pressure dynamically.
- *Blood pressure is measured in the unit torr, 1 torr = 133.3* Nm^{-2}=1mm of Hg
- *For normal healthy person the systolic pressure is 120 and diastolic pressure is 75 to 80Torr.*
- *At systolic pressure the blood flow is turbulent while it switches from turbulent to laminar at di-systolic pressure.*


This is a top view, and the baseball will curve to the right as seen by the pitcher.
This side of the spinning ball will increase the speed of the air flowing by it, and by the Bernoulli principle will reduce the air pressure.
F
Direction of throw
Direction of curve

The roughness of the ball's surface and the laces on the ball are important! With a perfectly smooth ball you would not get enough interaction with the air.

Do you know?

The cricket players usually polish one side of the ball and make rough other side of the ball to get the differential air pressure to swing a ball in air.

PRACTICE EXERCISE

30 mins Time Yourself

(1) Which of the given has the least coefficient of viscosity
(a) milk [✓ (b) water]
(c) tarcoal (d) engine oil

(2) The rain drop falling from the sky reach the ground with
[✓ (a) constant gravitational acceleration]
(b) constant terminal velocity
(c) constant pressure
(d) variable accelration

(3) Terminal velocity is
(a) uniform (b) maximum
[✓ (c) uniform and maximum] (d) neither uniform nor maximum

(4) When body moves with terminal velocity the acceleration in the body become
(a) zero (b) maximum
(c) variable [✓ (d) infinite]

(5) Terminal velocity is given by equation
(a) $V_t = gr^2\rho/\eta$ (b) $V_t = 2gr^2\rho/9\eta$
[✓ (c) $V_t = gr^2\rho/9\eta$] (d) $V_t = 9gr^2\rho/2\eta$

(6) A flowing liquid possess
(a) pressure (b) K.E
(c) P.E [✓ (d) all o f these]

(7) The flow of ideal fluid is always
(a) turbulent (b) streamline
[✓ (c) irregular] (d) straight line

(8) Which would be the least truck likely to sink into a soft ground
[✓ (a) truck loaded with four wheels]
(b) truck loaded with six wheels
(c) empty truck with four wheels
(d) empty truck with six wheels

(9) When fluid is incompressible then
(a) velocity of the fluid is constant
(b) flow of the fluid is straight line
[✓ (c) density of the fluid is constant]
(d) volume of the fluid is constant

(10) An ideal fluid flows through horizontal tube of variable diameter. The pressure is lowest where the
(a) velocity is highest (b) diameter is smallest
(c) diameter is largest (d) both a and b

(11) According to equation of continuity $A_1V_1 = A_2V_2$ = constant. The constant is equal to
(a) flow rate (b) volume of fluid
(c) mass of fluid (d) density of fluid

(12) Equation of continuity is obtained by apply in law of conservation of
(a) mass
(b) energy
(c) momentum
(d) all

(13) Bernoulli's equation is applicable to
[✓ (a) flow of liquids]
(b) viscosity
(c) surface tension
(d) all of these

(14) Speed of efflux can be determined by applying
(a) Bernoull`s theorem
[✓ (b) Torricelli`s theorem] $v = \sqrt{2g(h_1 - h_2)}$
(c) venture relation $P_A - P_B = \frac{1}{2}\rho v^2$
(d) stoke's law

(15) Blood vessels are
(a) rigid
[✓ (b) not rigid]
(c) of glass
(d) hard and solid

(16) If a steam of air is is blown under one of the pans of a physical balance in equilibrium, then pan will
(a) go up
(b) not effected
[✓ (c) go down]
(d) none of these

(17) A man standing near a fast moving train may fall
(a) on the train
(b) away from the train
(c) towards the train
(d) on himself

(18) For which position, maximum blood pressure in the body have the smallest value?
(a) standing straight
(b) sitting on chair
(c) sitting on ground
(d) lying horizontally

$P + \rho g h + \frac{1}{2}\rho v^2 = k$

$P \propto \frac{1}{\rho g h - \frac{1}{2}\rho v^2}$

(19) Two fog droplets have radii 2:3, their terminal velocities are
(a) 4:6
[✓ (b) 4:9] $v_t \propto r^2$ 4:9
(c) 2:9
(d) 4:3

(20) Burnoulli`s equation is obtained by applying law of conservation of
(a) mass
[✓ (b) energy]
(c) momentum
(d) fluid

(21) Venturi meter is used to measure
(a) fluid pressure
(b) fluid density
[✓ (c) fluid speed]
(d) fluid energy

(22) In cricket when a bowler produce swing, the ball will curve towards
[✓ (a) shinning side of the ball]
(b) rough side
(c) seam of the ball
(d) goes straight

(23) Stokes law is applicable if body has________ shape
(a) rough
(b) square
(c) circular
[✓ (d) spherical]

(24) The velocity of the flow of liquid through an orifice at eth bottom of a tank depends upon
(a) density of liquid
(b) height of liquid above the orifice
(c) gravity
[✓ (d) both b and c] $v = \sqrt{2g(h_1 - h_2)}$

(25) Systolic pressure is called
(a) low blood pressure
[✓ (b) high blood pressure]
(c) normal blood pressure
(d) abnormal blood pressure

(26) Instrument used to measure blood pressure is called
(a) venturimeter
(b) blood pressure
[✓ (c) sphygmomanometer]
(d) sonometer

(27) A chimney works best if air exposed to the chimney is
(a) stationary
(b) moving
(c) moving slowly
(d) moving fast

(28) Which one is venturi relation?
(a) $P_1-P_2 = 1/2\,\rho V_2^2$
(b) $V_2 = 2g\,(h_1-h_2)$
(c) $P + 1/2\rho V_2 + \rho gh = \text{constant}$
(d) $A_1V_1 = A_2V_2 = \text{constant}$

(29) The effect of the decrease in pressure with the increase of the speed of fluid in a horizontal pipe is known as
(a) Bernoulli`s effect
(b) Torricelli`s effect
(c) Venturi effect
(d) Stokes effect

(30) Ideal fluid is
(a) non-viscous
(b) incompressible
(c) steady flow
(d) possess all properties

(31) Laminar flow usually occurs at speeds.
(a) low
(b) high
(c) very high
(d) some time high and some time low

(32) For ———— flow the path of the fluid particles cannot be tracked.
(a) laminar
(b) streamline
(c) turbulent
(d) both (a) and (b)

(33) Sphygmomanometers measures blood pressure.
(a) statically
(b) dynamically
(c) some time static and some time dynamic
(d) none of these

(34) Carburetor of a car is a application of
(a) Venturi meter
(b) Bernoulli's equation
(c) Equation of continuity
(d) Torricelli's theorem

(35) The blood flow is ____________ flow at disystolic pressure
(a) laminar
(b) turbulent
(c) mixed
(d) none

(36) The profile of aeroplane wing which lifts it up is called as
(a) wing shape
(b) aerofoil profile
(c) curved profile
(d) none of these

(37) Bernoulli's equation is applicable for
(a) laminar flow
(b) turbulent flow
(c) both laminar and turbulent flow
(d) all kinds of flow

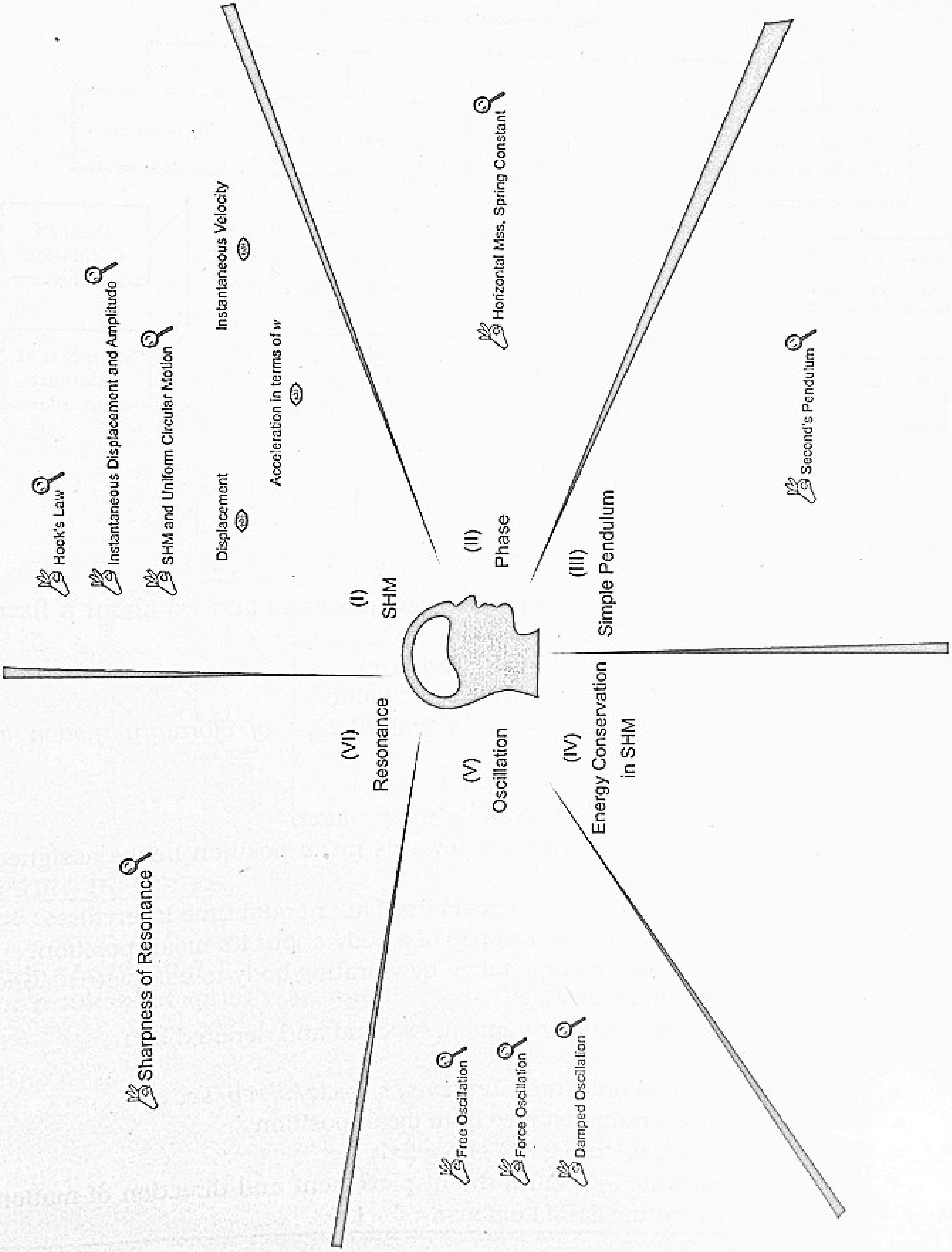
(38) The density of human blood is nearly equal to
(a) water
(b) honey
(c) mercury
(d) oil (kerosene)

(39) The speed of the fluid is maximum in the venturimeter at
(a) convergent duct
(b) divergent duct
(c) at end points
(d) at any point

(40) Ball pen function on the principle of
(a) viscosity
(b) surface tension
(c) Charle's law
(d) Boyle's law

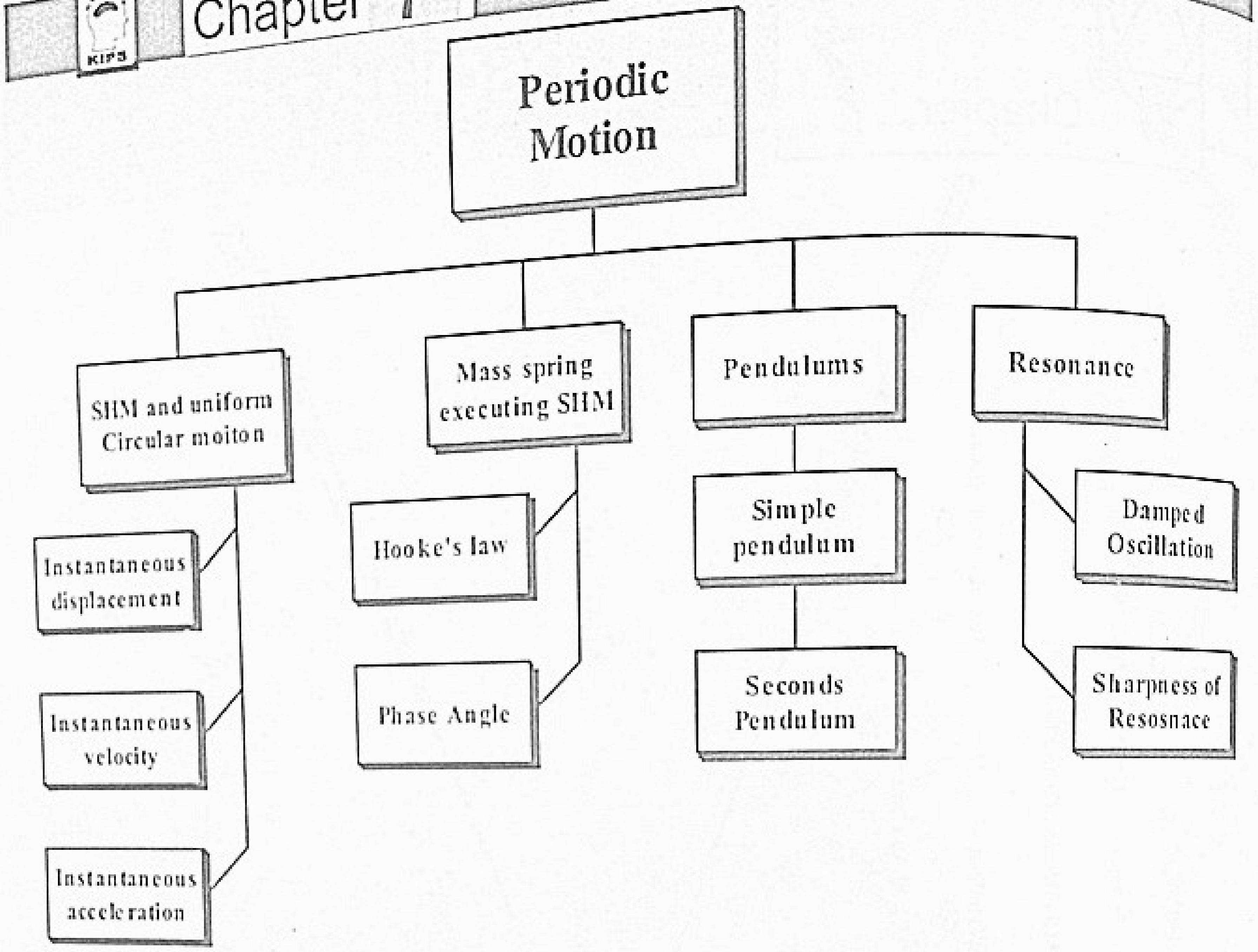
Chapter 7

OSCILLATIONS



Chapter 7

Oscillations



SIMPLE HARMONIC MOTION

- *Vibratory motion* is that in which a body moves to and fro about a fixed position along some path.

  e.g. 1- Motion of simple pendulum
  2- Motion of molecules of a solid
- *Simple harmonic motion(SHM) is a special type of vibratory motion in which:*

  1- $a \propto -x$
  2- *a is directed towards mean position.*
- *Restoring force* is always directed towards mean position hence assigned negative sign.
- *Periodic motion* is that which repeats itself after equal time intervals.
- *Vibration* is one complete round trip of a body about its mean position.
- *Time period* is defined as time taken by vibrating body to complete its one vibration and denoted by T.
- *Frequency* is number of vibrations per second and denoted by f

  $f = 1/T$

  Its unit is Hz, others units are vibrations/s, cycle/s, rev/sec
- *Amplitude* is maximum distance from mean position
- *Angular frequency* is $\omega = 2\pi/T \rightarrow \omega = 2\pi f$
- *Phase* is angle which specifies the displacement and direction of motion of the point executing SHM i.e phase $= \theta = \omega t$

- Initial angle at t = 0 is called *phase constant* and denoted by φ
- If phase constant ϕ=90, then displacement X= $X_0 \sin(\omega t+90) = X_0 \cos \omega t$

A HORIZONTAL MASS-SPRING SYSTEM

- For spring, Hooke's law states that;

  strain ∝ stress (within elastic limits)

  $F = kx$

  where k = F/x is called spring constant or force constant.

If a spring is cut in to two parts then spring constant of each spring is doubled.

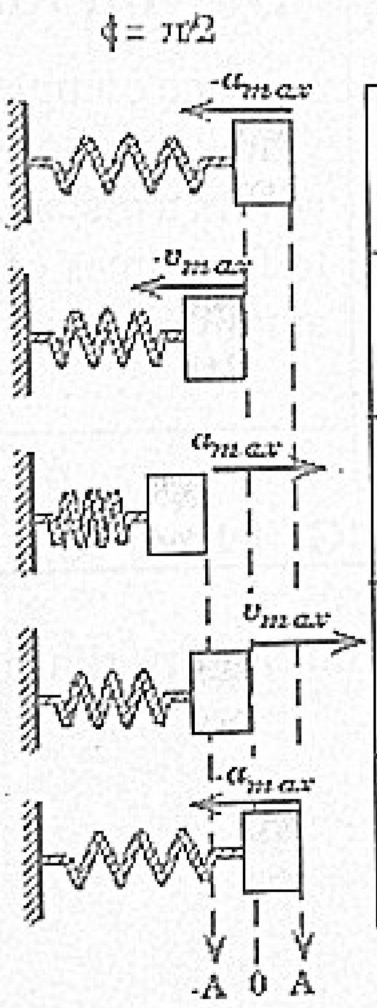
- *Mass attached to spring has SHM.* We get-

  $a = -k/m\ x$

  $a \propto -x$

- Mass-spring system has S.H.M and we can trace its waveform (pictorial display between time and displacement for S.H.M) by following relation;

  $x = x_0 \sin[2\pi/T \times t]$



Time t	Position $x(t)$	Velocity $v(t)$	Accel. $a(t)$	KE	PE
0	x_{max}	0	$-a_{max}$	0	PE_{max}
$\frac{T}{4}$	0	$-v_{max}$	0	KE_{max}	0
$\frac{T}{2}$	$-x_{max}$	0	a_{max}	0	PE_{max}
$\frac{3T}{4}$	0	v_{max}	0	KE_{max}	0
T	x_{max}	0	$-a_{max}$	0	PE_{max}

SPRING IN SERIES

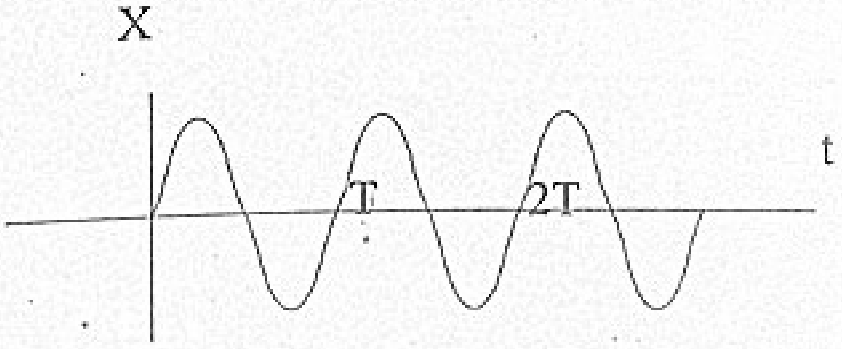
The resultant of spring constant in case of the series combination is

$$1/K = 1/K_1 + 1/K_2 + \dots\dots\dots\dots$$

Spring in Parallel

The resultant of spring constant in case of the parallel combination is

$$K = K_1 + K_2 + \dots\dots\dots\dots$$



- *Time period* of single mass attached to spring is given as;

  $T = 2\pi \sqrt{m/k}$

  $T \propto \sqrt{m}$; $T \propto 1/\sqrt{k}$

  Its displacement is given as;

  $x = x_0 \sin \omega t$
- *Instantaneous velocity* of mass 'm' attached to a spring is given as;

  $$V_{inst} = x_0\sqrt{\frac{k}{m}\left(1-\frac{x^2}{x_o^2}\right)} = \sqrt{\frac{K}{m}\left(x_0^2 - x^2\right)}$$
- *Maximum speed* of mass attached to spring is given as;

  $V_o = x_o \sqrt{k/m}$
- Instantaneous and maximum speed of mass attached to spring are related as;

  $$V_{inst} = V_o\sqrt{\frac{\left(1-x^2\right)}{x_o^2}}$$

Velocity	At mean position max	At extreme position zero
Acceleration	At mean position minimum	At extreme positions maximum

Do you know?

In a one complete vibration a body covers a distance equal to four times of the amplitude.

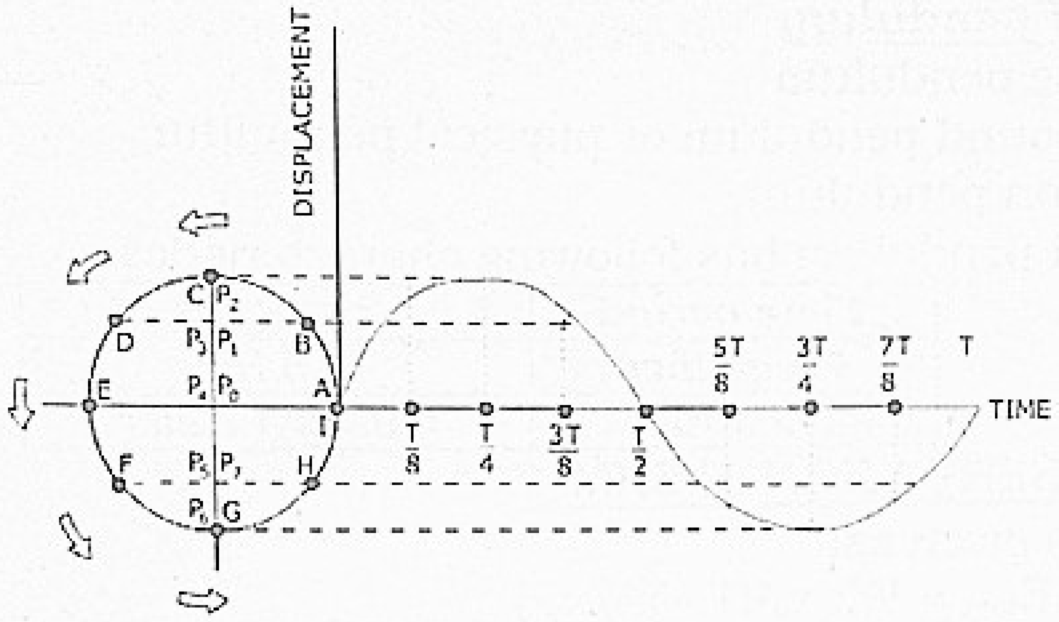
MOTION OF PROJECTION OF A BODY MOVING IN A CIRCLE ON DIAMETER

- Motion of projection of a body moving in a circle on diameter with constant speed is S.H.M
- Its *acceleration* is given as;

  $a = -\omega^2 x$
- *Time period* of projection is given as;

  $T = 2\pi/\omega$
- *Speed of projection* is given as;

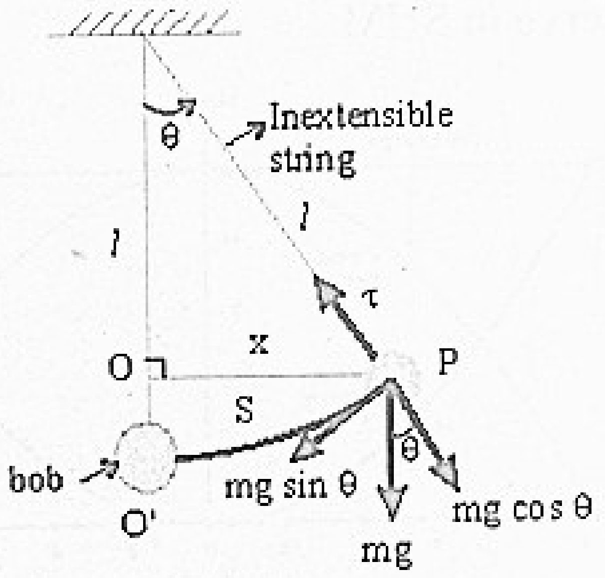
  $V = \omega\sqrt{r^2 - x^2}$ where r= radius of the circle = amplitude of S.H.M
- *Projection speeds up when moving towards the centre of circle.*
- *Projection slows down when moving away from the centre of circle.*
- If speed ω of body is not constant then projection does not have S.H.M but has vibratory motion, which is non-S.H.M.



SIMPLE PENDULUM

It consists of a heavy point mass suspended from a rigid support by means of almost weightless and inextensible string.

- *Galileo invented simple pendulum.*
- Motion of simple pendulum is S.H.M if there is no damping.
- Damping force reduces the amplitude of simple pendulum continuous and finally its motion is stopped.



- In absence of damping force, *restoring force* on simple pendulum is given as;

  $F_r = -mg\sin\theta$
- Equation of *acceleration* of simple pendulum for small amplitude is;

  $a = -(g/l)x$
- *Time period and frequency* of simple pendulum are given as;

  $T = 2\pi\sqrt{l/g}$ and $f = \frac{1}{2\pi}\sqrt{g/l}$
- If amplitude of simple pendulum is not small then, it has non-S.H.M as $a = -g\sin\theta$ and we know that $\sin\theta = \theta$ only when θ is small.

Point to Ponder

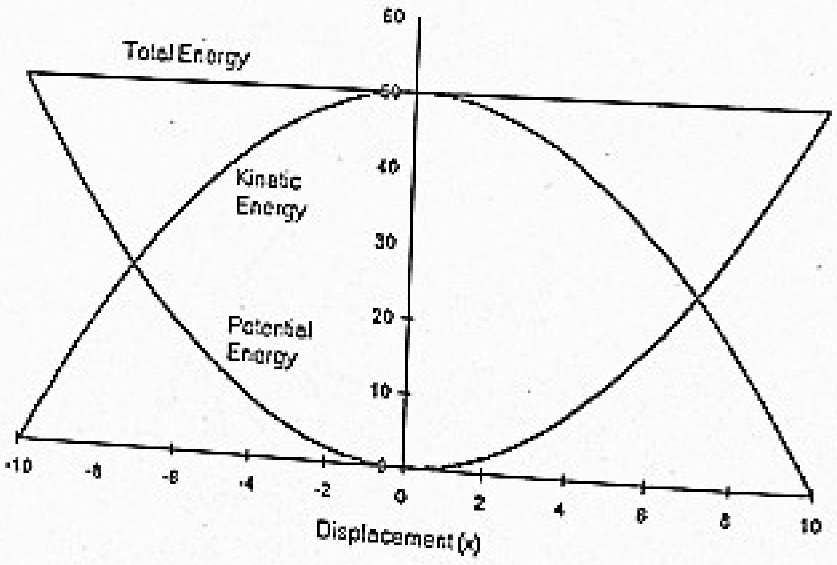
The time period of simple pendulum is independent of mass and its amplitude.

- ***Kinds of pendulum***
  (a) simple pendulum
  (b) compound pendulum or physical pendulum
  (c) torsion pendulum
- *A second pendulum has following characteristics:*

Time period	*2 seconds*
Frequency	*0.5 Hz*
Length	*0.99 or 1 meter*

ENERGY CONSERVATION IN SHM

- Its K.E is given as;
  $K.E_{inst} = \frac{1}{2}k\,x_o^2(1 - x^2/x_o^2)$
  $(K.E)_{max} = kx_o^2/2$ It is at mean position.
  $(K.E)_{min} = 0$ It is at extreme position.
  $K.E_{inst} = (K.E)_{max}\,(1 - x^2/x_o^2)$
- Its P.E is given as;
  $P.E_{inst} = kx^2/2$
  $(P.E)_{max} = kx_o^2/2$ It is at extreme position.
  $(P.E)_{min} = 0$ It is at mean position.
- Total energy of system = $\frac{1}{2}kx_o^2$
  energy remain conserve in SHM



In one vibration K.E. attains its maximum value twice.

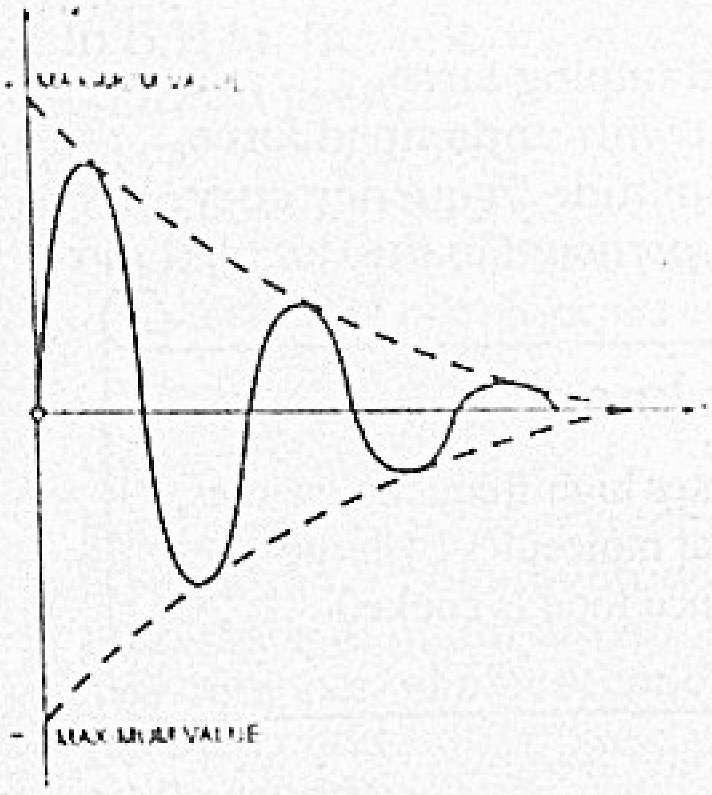
FREE & FORCED OSCILLATIONS

- Oscillation of a system is called free *vibration* if it oscillates without the interference of an external force.
- Frequency of free oscillation is called *natural frequency of the system*
- When a system performs oscillation only in the presence of external periodic force its vibration is called *forced oscillation.*
- A physical system under going forced vibration is known as *driven harmonic oscillator.*

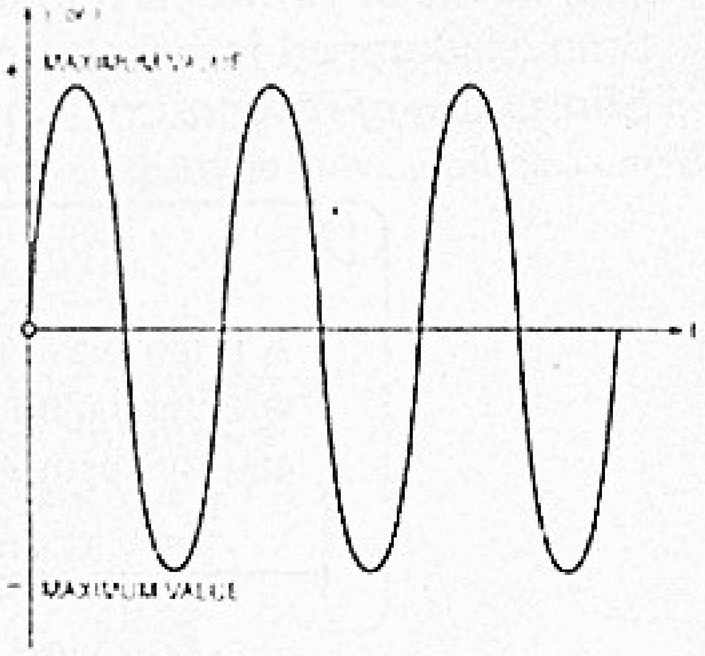
DAMPED OSCILLATION

Such oscillations in which the amplitude decreases steadily with time are called as damped oscillations.

- In shock absorber of a car critical damping is applied.



(a) Damped Oscillations



(b) Undamped or Sustained Oscillations

Do you know?

Damping is a process where by energy is dissipated from the oscillating system.

RESONANCE

A phenomenon of increase in amplitude of a body (capable of vibrating) under the action of a periodic force whose time period is equal to natural time period of body.

OR

Specific response of a system to external periodic force whose time period is equal to natural time period of a body.

OR

Process in which one body transfers its vibrations to nearby body whose natural time period is agreeable to it.

- For tuning circuit of T.V or radio or mobile phone, electrical resonance takes place at following frequency;

  $f = 1/(2\pi\sqrt{LC})$
- Magnetic resonance (MRI) is a process of getting images of internal origins of human body due to incidences of photo from time varying magnetic field. It is less damaging than X-rays imaging process
- Suspension bridge may brake down due to vibration with increased amplitude caused by resonance.
- We get tired on walking briskly because of force oscillation fed our legs for resonance.
- Loose parts of car produce noise at specific speed due to resonance.

SHARPNERS OF RESONANCE

- Amplitude of vibration decreases with damping force
- Amplitude of vibration remain constant with undamped force
- Smaller damped force, sharp is the amplitude frequency curve.
- *Sharpness of resonance is inversely proportional to the damped force.*

Do you know?

A microwave oven generates high frequency waves, which heat up water and fat molecules by large energy absorption, and hence food is cooked.

PRACTICE EXERCISE

30 mins Time Yourself

(1) In vibratory motion

(a) P.E. remains constant
(b) K.E. remain constant
(c) total energy remain constant
(d) total momentum remain constant

(2) The waveform of S.H.M. is

(a) standing wave
(b) sine wave
(c) square wave
(d) rectangular waves

(3) If the spring constant is halved then the new constant will be

(a) 3k
(b) 2k
(c) 4k
(d) k/2

(4) In S.H.M, the velocity of a particle is maximum at

(a) mean position
(b) extreme position
(c) middle between mean and extreme position on the right side
(d) middle between mean and extreme position on the left side.

(5) The acceleration of a projection on the diameter for a particle moving along a circle is

(a) $\omega^2 x$
(b) ωx^2
(c) $-\omega^2 x$
(d) $-\omega x^2$

(6) Total energy of a body executing S.H.M, is directly proportional to

(a) square root of amplitude
(b) the amplitude
(c) reciprocal of amplitude
(d) square of amplitude

(7) The time period of a second's pendulum is

(a) 4 seconds
(b) 3 seconds
(c) 2 seconds
(d) 6 seconds

(8) The length of simple pendulum on the surface of earth is 1m, its length on the surface of the moon, where g is 1/6th value of g on the earth is

(a) Remain same
(b) 6m
(c) 1/6m
(d) 1/36m

(9) If length of a pendulum becomes four times, then its time period will become

(a) four times
(b) six times
(c) eight time
(d) two times

(10) The force responsible for the vibratory motion of the simple pendulum is

(a) mg cosθ
(b) mg sinθ
(c) mg tanθ
(d) mg

(11) Then tension in the string of simple pendulum is

(a) remain constant
(b) maximum at the extreme position
(c) maximum at the mean position
(d) zero at the mean position

(12) Simple harmonic motion is a type of
(a) rotational motion (b) circular motion
(c) musical arrangement (d) vibratory motion

(13) The SI unit of force constant is identical with that of
(a) force (b) pressure
(c) surface tension (d) loudness

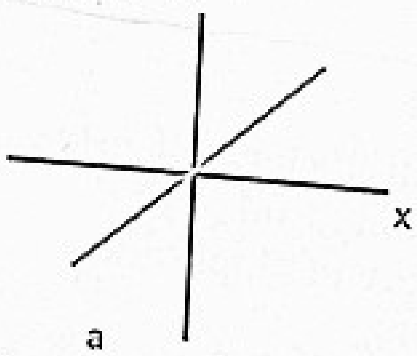
(14) When the amplitude of a wave become double, its energy become
(a) double (b) four times
(c) one half (d) none time

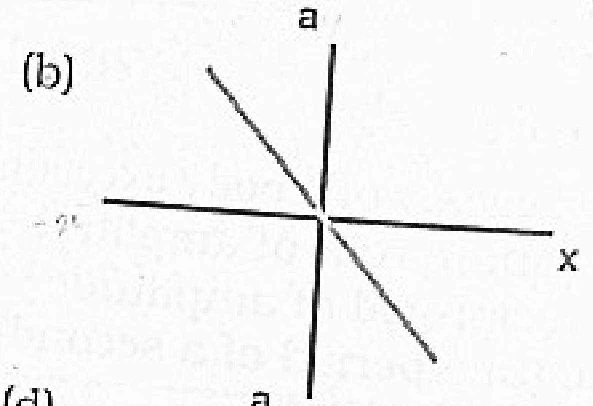
(15) A simple pendulum suspended form the ceiling of a lift has time period T when the lift is at rest. When the lift falls freely then its
(a) time period becomes zero (b) acceleration becomes zero
(c) vibration is stopped (d) frequency becomes infinity

(16) The energy of SHM is maximum at
(a) mean position (b) extreme position
(c) in between mean and extreme (d) all positions during SHM

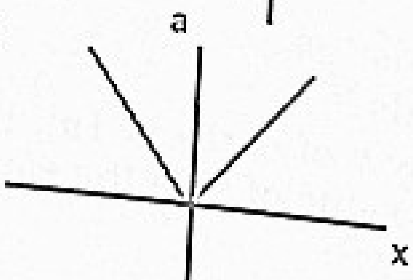
(17) If a hollow bob of a simple pendulum be filled with mercury that drains out slowly, its time period
(a) increases continuously (b) decreases continuously
(c) remain same (d) first increases then decreases

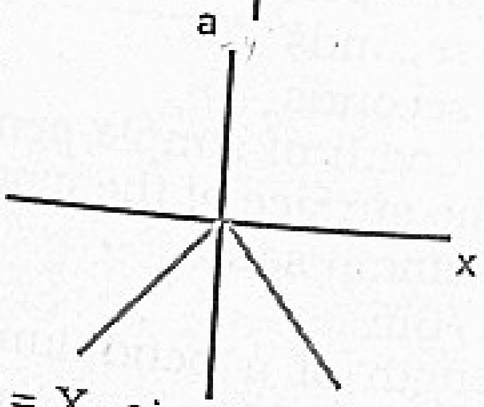
(18) Which one is the correct graph between acceleration 'a' and displacement 'd' for SHM?

(a)


(b)


$a \propto -x$

(c)


(d)


(19) The displacement of SHM is written as $X = X_0 \sin\omega t$ if displacement is written by $X = X_0 \cos\omega t$ then phase constant will be equal to
(a) 0° (b) 45°
(c) 90° (d) 180°

(20) For what displacement the P.E becomes 1/4 of its maximum value?
(a) $x = x_0$ (b) $x = x_0/2$
(c) $x = x_0/4$ (d) $x = x_0^2/2$

(21) Sharpness of resonance is
(a) directly proportional to damping force
(b) inversely proportional to damping force
(c) equal to square of damping force
(d) equal to square of damping force

(22) Which one does not work according to resonance?
(a) T.V (b) radio
(c) microwave oven (d) bulb

(23) Which of the given equation is correct in SHM
(a) T.E = $\frac{1}{2}kx_o^2$ (b) T.E = $K.E_{max}$
(c) T.E = $P.E_{max}$ (d) all are correct

(24) Phase of SHM describes
(a) displacement only
(b) direction of motion only
(c) both displacement and direction of motion
(d) neither displacement nor direction of motion

(25) Natural frequency of simple pendulum depends upon
(a) its mass (b) its length
(c) square of its length [✓ (d) square root of its length]

(26) Electrical resonance is observed in
(a) radio
(b) microwave oven
(c) both in radio and microwave oven
(d) neither in radio nor in microwave oven

(27) Total distance traveled by bob of simple pendulum in one vibration is equal to
(a) amplitude (b) square of amplitude
(c) twice of amplitude (d) four times of amplitude

(28) When K.E energy of SHM is maximum, its
(a) P.E is zero
(b) acceleration is zero
(c) restoring force is zero
(d) all P.E acceleration & restoring force are zero

(29) In damped harmonic oscillation, which one decreases?
(a) amplitude of vibration (b) energy of vibration
(c) both amplitude and energy (d) neither amplitude nor energy

(30) Forced vibration are known as
(a) simple harmonic vibration (b) natural vibration
(c) driven harmonic vibration (d) free vibration

(31) Mass attached to a spring executes.
(a) vibratory motion (b) rotatory motion
(c) S.H.M (d) both (a) and (c)

(32) At Murree Hills (Assume value of g changes). If we use a simple pendulum as time standard then one second duration will.
(a) increase (b) decrease
(c) remains same (d) is zero

(33) The period of oscillation of mass attach to the spring is 1sec, then for the length of 4m the period will be

[✓ (a) 2sec] (b) 4sec

(c) 1/2sec (d) 1/4sec

(34) The projection of the particle moving in a circle with non-uniform angular speed executes.

(a) S.H.M (b) Vibratory motion

(c) Both (b) and (d) [✓ (d) None S.H.M]

(35) Displacement of the body in S.H.M is equal to amplitude when body is at

(a) mean position (b) else where

(c) extreme position (d) none

(36) For a simple pendulum the restoring force is caused by

[✓ (a) gravity] (b) spring

(c) hand (d) all of these

(37) The distance covered by a body in one complete vibration is 20cm. What is the amplitude of body

(a) 10cm (b) 5cm

(c) 15cm (d) 7.5cm

(38) If the mass of the spring oscillator become half the frequency will be

(a) Quadruple (b) Half

[✓ (c) double] (d) remain same

(39) In case of a simple pendulum, the cause of damping is

(a) drag force of air (b) gravity

(c) tension in string (d) none of these

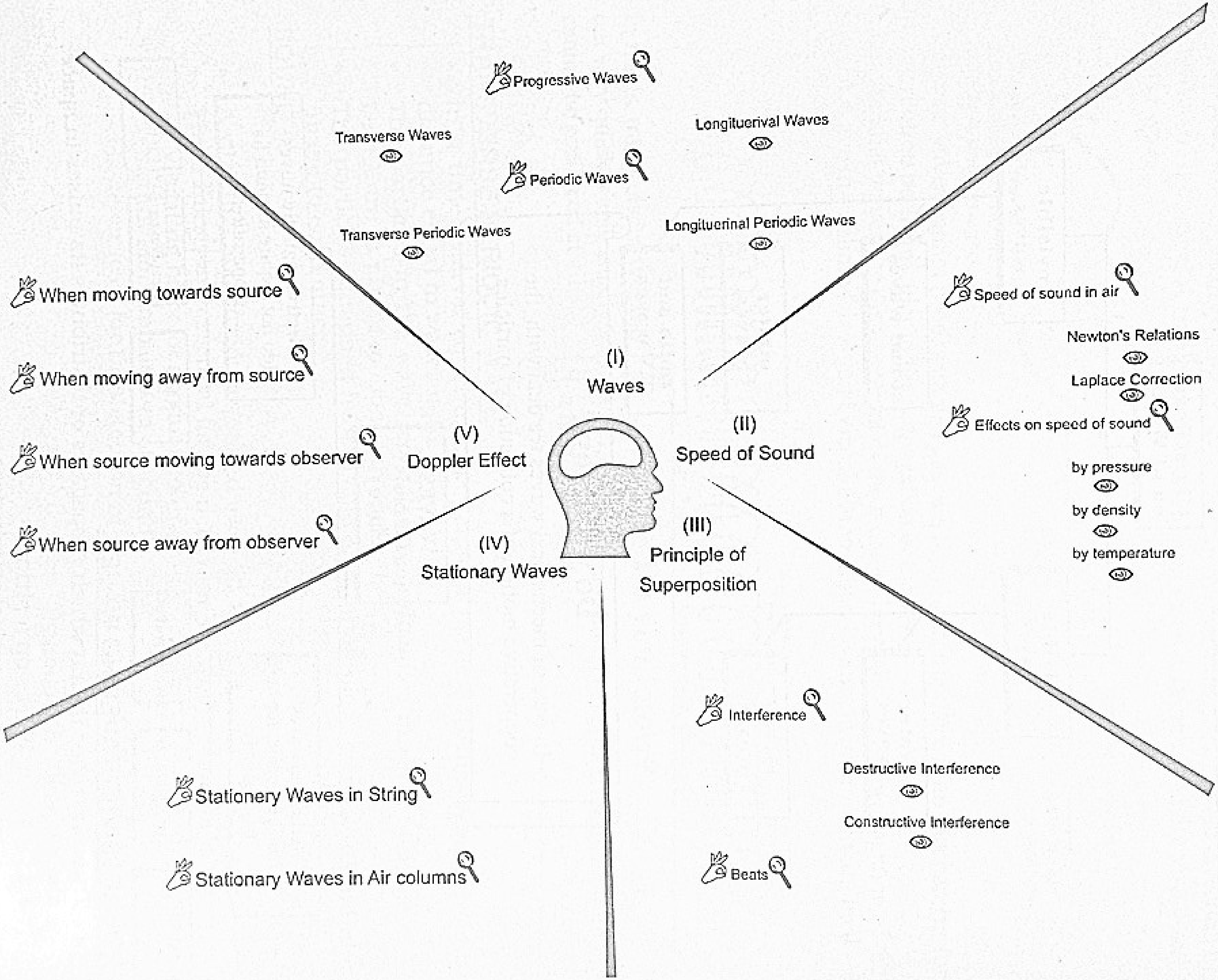
(40) The energy absorbed by a body is ______________ at resonance.

(a) maximum as well minimum (b) minimum only

[✓ (c) maximum only] (d) zero

Chapter 8

WAVES

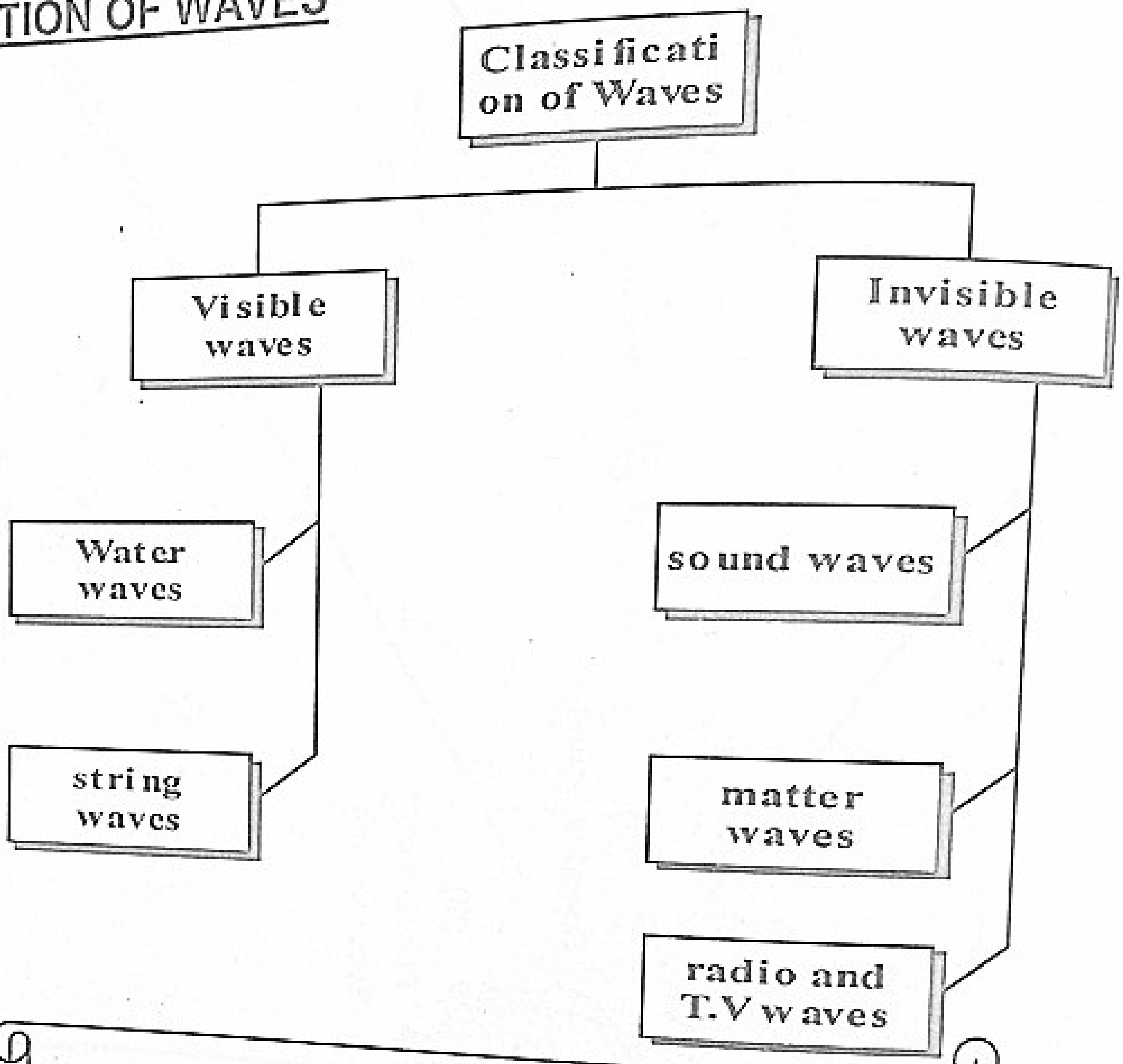


- (I) Waves
  - Progressive Waves
  - Periodic Waves
  - Transverse Waves
  - Transverse Periodic Waves
  - Longituerival Waves
  - Longiturinal Periodic Waves
- (II) Speed of Sound
  - Speed of sound in air
    - Newton's Relations
    - Laplace Correction
  - Effects on speed of sound
    - by pressure
    - by density
    - by temperature
- (III) Principle of Superposition
  - Interference
    - Destructive Interference
    - Constructive Interference
  - Beats
- (IV) Stationary Waves
  - Stationery Waves in String
  - Stationary Waves in Air columns
- (V) Doppler Effect
  - When moving towards source
  - When moving away from source
  - When source moving towards observer
  - When source away from observer

INTRODUCTION

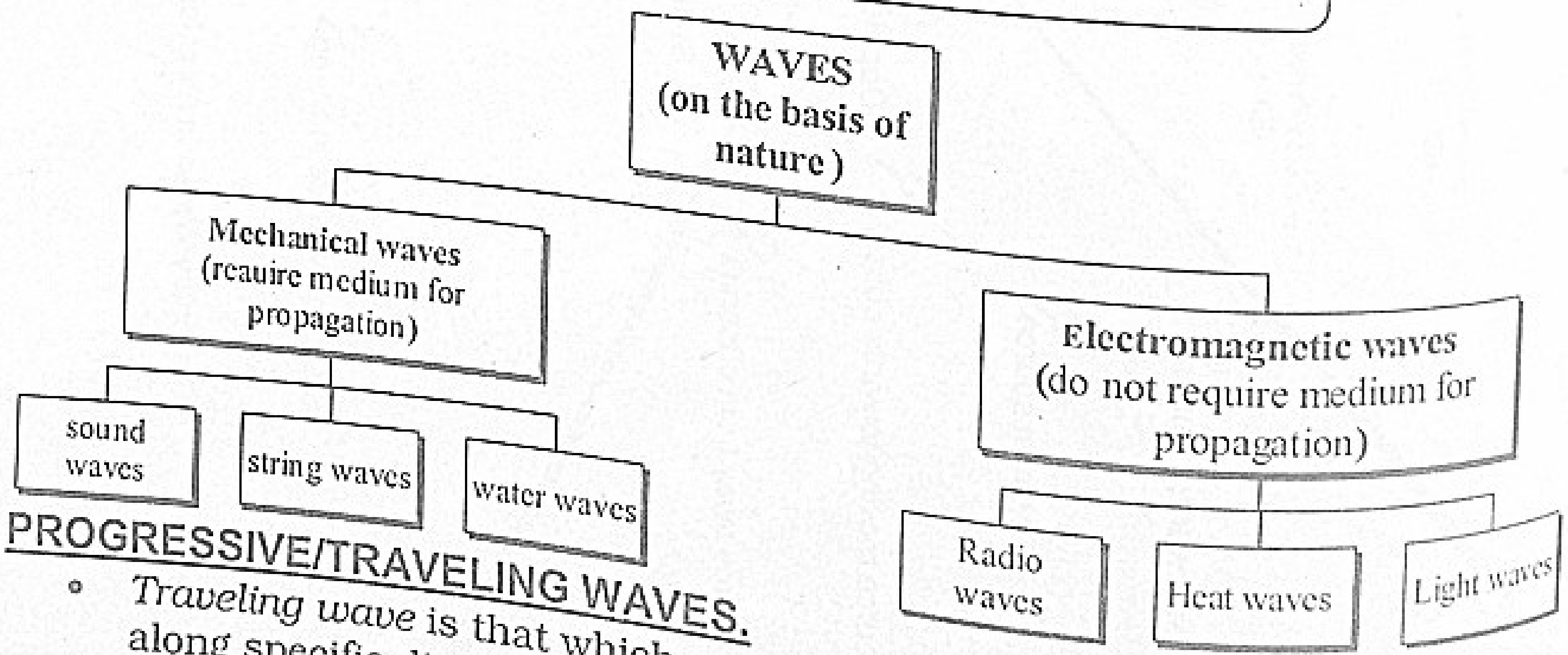
- *Wave is due to disturbance created in a medium.*
- Waves transport energy without transporting matter.

CLASSIFICATION OF WAVES



Do you know?

In case of mechanical waves we deal with the cooperative motion of a collection of particles.


WAVES (on the basis of nature)
Mechanical waves (reauire medium for propagation)
Electromagnetic waves (do not require medium for propagation)
sound waves
string waves
water waves
Radio waves
Heat waves
Light waves

PROGRESSIVE/TRAVELING WAVES.

- *Traveling wave* is that which propagates or distributes its pulses in space along specific direction.

  e.g. 1- Waves on a string

  2- Waves on a water surface

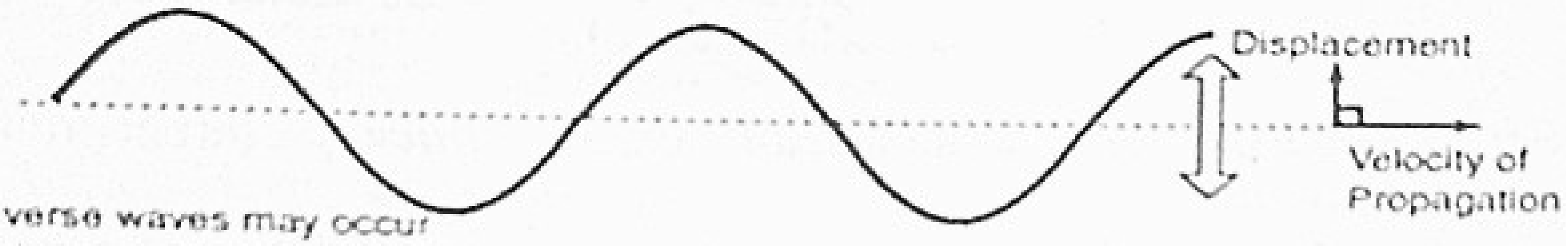
Chapter 8 Waves

PERIODIC WAVES

Periodic waves are those, which are repeated in regular interval of time

- Periodic wave may be transverse may be longitudinal.

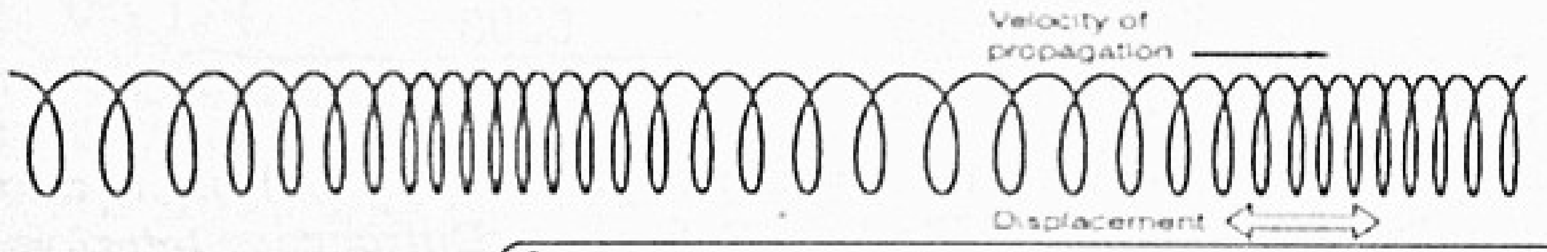
For transverse waves the displacement of the medium is perpendicular to the direction of propagation of the wave. A ripple on a pond and a wave on a string are easily visualized transverse waves.



Transverse waves may occur on a string, on the surface of a liquid, and throughout a solid

Transverse waves cannot propagate in a gas or a liquid because there is no mechanism for driving motion perpendicular to the propagation of the wave.

In longitudinal waves the displacement of the medium is parallel to the propagation of the wave. A wave in a "slinky" is a good visualization. Sound waves in air are longitudinal waves.



In fluids, transverse waves die out very quickly and usually cannot be produced at all.

Do you know?

The waves transport both energy and momentum in a medium

TRANSVERSE PERIODIC WAVE

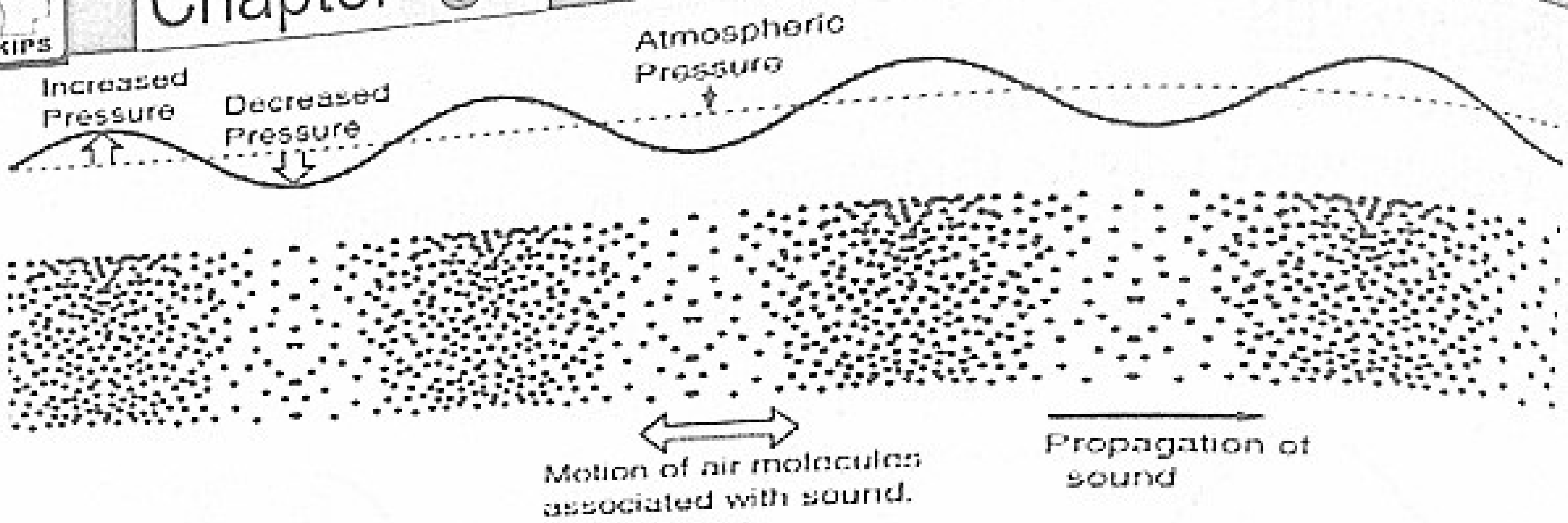
imp

- In a time interval equal to time period a particle in the wave travels a distance equal to wavelength.
- The particles in the wave separated by a distance integral multiple of λ i.e. $n\lambda$ are **in phase** motion with each other.
- The particles separated by a distance odd multiple of λ $(n+1/2)\lambda$ are **out phase** to each other.

SOUND

- A vibrating body produces sound waves ($\lambda \approx 1$m).
- Three things are essential for the detection of sound.
  1- Vibrating body for production of sound
  2- Medium for propagation of sound
  3- Listener (ear) for the detection of sound

Chapter 8 Waves



- *Sound waves are longitudinal waves having three dimensional propagation in air.*
- Longitudinal sound waves consist of compression and rarefaction.
- *Compression* is region where crowding of particles of medium is maximum.

Wave	*Speed (m/s)*
EM waves	300 000 000
Sound in air	340
Sound in water	1500
Sound in steel	5000

$3\times10^8 ms^{-1}$

- *Rarefaction* is region where crowding of particles of medium is minimum.
- *Sound waves produce Reflection, Refraction, Diffraction, Interference but not polarization because sound waves are longitudinal.*

Sound Intensity

Sound intensity is defined as the sound power per unit area. The usual context is the measurement of sound intensity in the air at a listener's location. The basic units are watts/m^2 or watts/cm^2

The most common approach to sound intensity measurement is to use the decibel scale:

$$I(dB) = 10\log_{10}\left[\frac{I}{I_0}\right]$$

Intensity in decibels

VELOCITY OF SOUND IN AIR

- *Newton was the first* to derive a formula for speed of sound in any medium. Its base was that sound waves travel in air isothermally.

  $V = \sqrt{E/\rho}$

  where E = modulus of elasticity of medium

  ρ= density of medium
- In gases, sound travels in the form of compressional wave; and gases have bulk modulus of elasticity. So for gases, we get-

  $V = \sqrt{E_{bulk}/\rho}$
- *Bulk modulus* of elasticity is ratio of stress to volume strain

  $E_{bulk} = P/(\Delta V/V)$
- Newton proved that for air $E_{bulk} = P$, so that- at S.T.P.

  $V = \sqrt{P/\rho}$

  $= \sqrt{hdg/\rho}$ (where d = density of mercury)

  $= \sqrt{76 \times 13.6 \times 981/0.001293}$

$= 28100$ cm/s
$= 281$ m/s

- *%age error in Newton's calculation was 16%* because of assumption that sound propagates through air isothermally.
- *Laplace corrected Newton's formula by proposing that "sound wave does not propagates in air isothermally but adiabatically, as air is a thermal insulator".*
- Laplace's formula is given as;

  $V = \sqrt{\gamma P / \rho}$

  $\gamma = C_p/C_v = 1.42$ (for air)
- *Experimentally it is found that speed of sound increases by 0.61 m/s or 61 cm/s for each 1°C rise in temperature.*

Effect of moisture

Water vapours are lighter than air thus the presence of moisture in air reduces density hence the speed of sound increases in such cases.

- *Dependence of velocity of sound*
  1- V is independent of pressure
  2- $V \propto 1/\sqrt{\rho}$
  3- $V \propto \sqrt{T}$
  4- $V_1/V_2=\sqrt{T_1/T_2}$
  5- $V_t = V_0 + 0.61\ t$

Do you know?

The speed of sound in hydrogen is four times more than the speed of sound in oxygen at same

PRINCIPLE OF SUPERPOSITION

The resultant displacement of a point of medium is equal to sum of individual displacement produced by each move. This is called principle of superposition

$$Y_{total} = Y_1 + Y_2\ Y_3 + \dots\dots + Y_n$$

Applications

1. ***Interference:***It is produced by *two waves of same frequencies, which are traveling in the same direction.*
2. ***Beats:***These are produced by *two waves of slightly different frequencies traveling in the same direction*
3. ***Stationary Waves:*** These are produced by *two waves of equal frequency and equal amplitude traveling along same line in opposite direction.*

INTERFERENCE OF SOUND

Superposition (mixing up) of two identical sound waves while passing through same medium propagating along same direction is called interference.

- ***Conditions for inference***
  1- coherent waves
  2- same medium
  3- same direction
  4- identical waves
  5- Sources of sound should be close to each other
- *In constructive interference,* two interfering sound waves reinforce each other, so that the resultant is a louder sound.

Condition for constructive interference

Path difference = $n\lambda$ where $n = 0, \pm 1, \pm 2, \ldots\ldots$

- *In destructive interference,* two interfering sound cancel each other's effect , so that the resultant loudness of sound is become fainter.

Condition for destructive interference

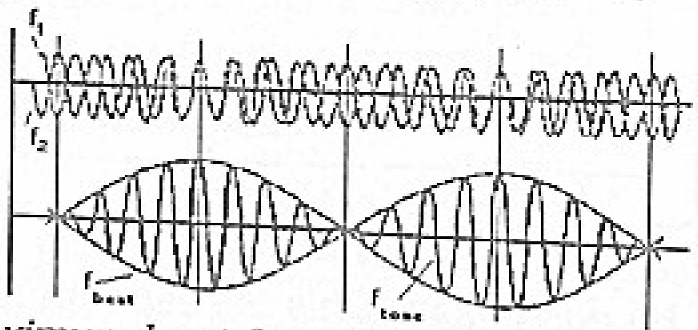
Path difference = $(n + \frac{1}{2})\lambda$ where $n = 0, \pm 1, \pm 2, \ldots\ldots$

- *Echoing zone* is region of constructive interference
- *Silence zone* is region of destructive interference
- *Path difference* is the difference between lengths of paths traveled by two waves.

BEATS

The periodic alterations of sound between maximum and minimum loudness are called beats

- Beats are produced by the interaction of two waves having slightly different frequencies traveling in same medium along same direction.
- *Beat frequency* is number of beats per second.
- Difference between frequencies of two tuning forks producing beats is given as $f_{beat} = f_A - f_B$



> **Do you know?**
>
> If frequency of a tuning fork is 32 Hz then after 3/4 sec, it will complete 24 vibrations.

Maximum beat frequency for normal human ear is 10Hz.

- Beats are used to:
  1- Determine unknown frequencies
  2- Tune musical instruments

REFLECTION OF WAVES

- All kinds of wave shows reflection i.e. reflection is wave characteristic
- *When reflection of wave takes place from denser boundary, the phase of waves reverses. In this case, reflection co-efficient is maximum and transmission co-efficient is almost zero except for quantum mechanical transmission of particle from potential barrier.*
- *When reflection takes place from rare boundary, there is no phase reversal. In thiscase, reflection co-efficient and transmission coefficient have considerable values*

> **Do you know?**
>
> The reflected wave has the same wavelength and frequency but its phase may change depending on the nature of medium.

TRANSMISSION OF WAVES

- Amplitude of transmitted wave is less than that of incident wave because some of energy of incident wave is wasted at point of discontinuity.

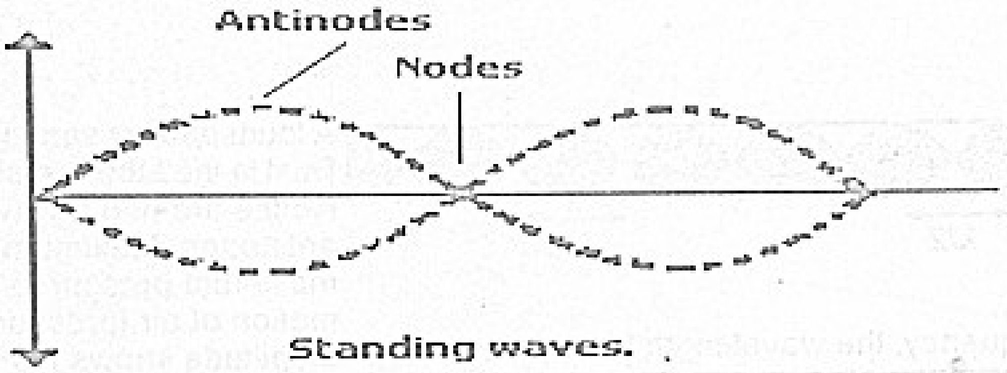
- Frequency of transmitted wave is same as that of incident wave but its velocity depends on density of medium as given below;

  $V \propto 1/\sqrt{\rho}$

- Since velocity of transmitted wave is different from original wave, therefore, wave length (λ) changes as frequencies of both waves are equal

STANDING WAVES

- Interaction of two identical waves traveling opposite to each other in the same medium, gives rise stationary or standing waves
- *Both constructive and destructive interference takes place in formation of stationary waves.*
- Points of constructive interference are called *antinodes* while points of destructive interference are called *nodes* as shown



Standing waves.

- Amplitude is maximum at antinodes and minimum (zero) at nodes.
- *Nodes* are stationary points whereas *antinodes* are points that vibrate with maximum amplitude.
- *Two consecutive nodes or antinodes are separated by distance equal to λ/2 and an antinode and its consective node by λ/4.*

2 vib
x3/4
4v

> **Do you know?**
>
> The energy stored in anti nodes at their extreme position is wholly potential while at equilibrium position the energy stored is usually kinetic but total energy remains the same.

STANDING WAVES IN STRECTHED STRING

Imp

- At fixed end of string always node is formed while at free end of string always antinode is formed.
- *If string is fixed at both ends,* then number of nodes is one greater than no. of antinodes.

  N = A+1

- *If string is free at one end,* then no. of antinodes is equal that of nodes.

  A = N

- *Speed* of string wave is

  $V = \sqrt{T/m} = \sqrt{F/m}$

  m is called linear mass density.

- *Frequency* of stationary wave is

  $f_n = n f_1$

> **Do you know?**
>
> The speed of stationary waves is independent of the No. of loops.

where $f_1 = \frac{1}{2l}\sqrt{\frac{T}{m}}$

- *Stationary waves obey quantization of frequency.*

$f_n = n\, f_1$; $n = 1, 2, 3, \ldots$

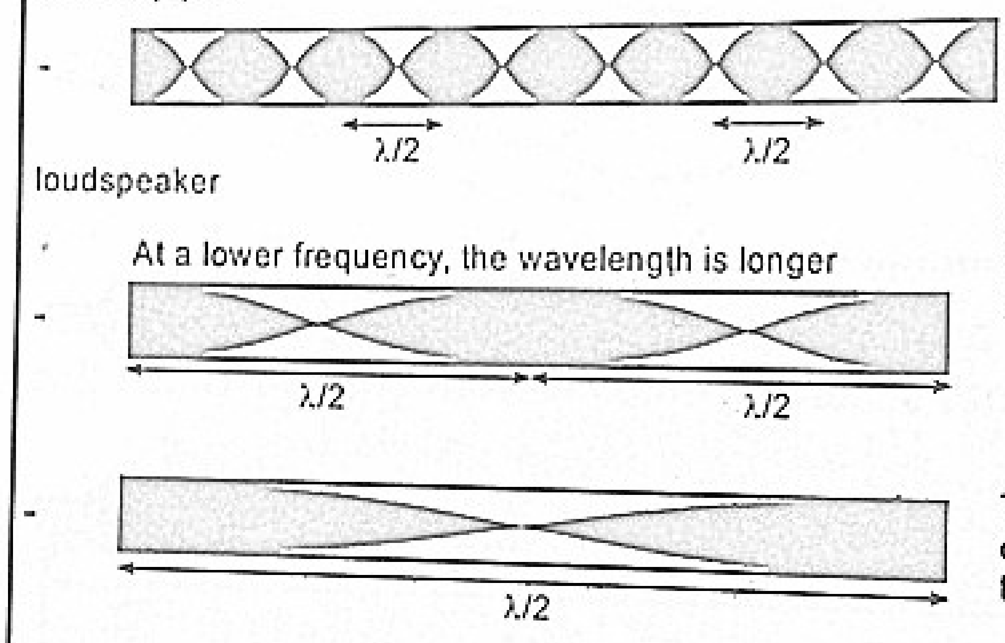
where f_1 is the lowest frequency (fundamental or basic frequency) at which first stationary wave is formed.

All other frequencies ($f_2, f_3, \ldots, f_n$) which are integral multiple of fundamental frequencies are called overtones or harmonics.

STANDING WAVES IN AIR COLUMNS

Standing waves in pipes

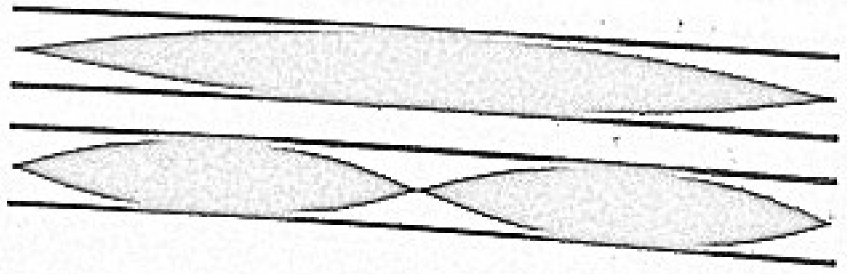
Closed pipes



A loudspeaker sends a sound into a long tube. Dust in the tube can show nodes and antinodes. Nodes are half a wavelength apart. So are antinodes. Maximum amplitude shows maximum pressure variation and minimum motion of air (pressure antinode). Minimum amplitude shows minimum pressure variation and maximum motion of air (pressure node).

The fundamental: The lowest frequency which can form a standing wave has wavelength equal to twice the length of the tube

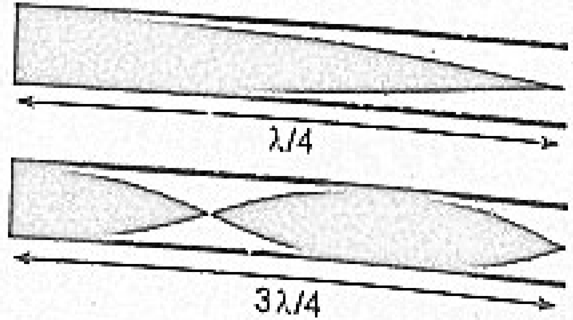
Pipes open at both ends



Sound can be reflected from an open end as well as from a closed end.

This is how open organ pipes and flutes work.

Pipes closed at one end



Pipes closed at one end are shorter, for the same note.

A clarinet is like this. An oboe is too, but with a tapered tube.

Some organ pipes are stopped at one end.

Frequencies of standing waves

	pipes open or closed at both ends strings fixed at both ends	pipes open at one end
length L	$L = n\lambda/2$	$L = (2n-1)\lambda/4$
fundamental	$f = v/2L$	$f = v/4L$
harmonics	$2f$ $3f$ ... nf	$3f$ $5f$ ... $(2n-1)f$

where n = 1,2,3.......

- *Fundamental frequency of open pipe = 2 x fundamental frequency of closed pipe*
- *No. of harmonics in open pipe = 2 x No. of harmonics in closed pipe*

Point to Ponder

The open end of the organ pipe behaves as antinode while the closed end behave as node in case of stationary waves through organ pipe. Why.

DOPPLER'S EFFECT

Apparent change in pitch (frequency) of sound is due to relative motion of source and observer.

- Doppler's effect was discovered by Doppler, an Australian physicist, in 1845.
- *Apparent frequency of sound heard by* ***stationary listener*** *due to source* ***moving towards*** *him at speed 'u' is given as;*

  $f' = (v/v\text{-}u)\, f$ $\qquad f' > f$
- *Apparent frequency of sound heard by* ***stationary listener*** *due to source* ***moving away*** *from him at speed 'u' is given as;*

  $f' = (v+u/v)\, f$ $\qquad f' < f$
- *Apparent frequency of sound heard by a* ***person moving towards*** *a* ***stationary source with*** *speed 'u' is given as;*

  $f' = (v+u/v)\, f$ $\qquad f' > f$
- *Apparent frequency of sound heard by a listener* ***moving away from*** *a* ***stationary source with*** *speed 'u' is given as;*

  $f' = (v\text{-}u/v)\, f$ $\qquad f' < f$
- *When source and listener move in same direction, then frequency of sound heard by listener is given as;*

  $f' = (v\text{-}u_o/v\text{-}u_s)\, f$

where v *= true speed of sound* $\quad u_o$ *= speed of listener* $\quad u_s$ *= speed of source*

- *When source and observer are moving away from each other, then frequency of sound heard by listener is given as;*

$$f' = (v+u_o/v-u_s)\,f$$

- Light observes Doppler's effect too.

Applications of Doppler's effect

1- Ships and submarine (sonar devices)
2- Bats (for traveling)
3- Radar (for detection)
4- Determining velocity of a star w.r.t earth
5- to monitor blood flow in major arteries.

- When a start is moving away from earth then wavelength of light increases and red shift of spectrum is observed
- When a start is moving toward the earth then wavelength of light decreases and blue shift of spectrum is observed

TOP Study

PRACTICE EXERCISE

30 mins Time Yourself

(1) Which of the following is not the property of sound?
(a) It can travel in vacuum
(b) It is reflected
(c) It shows phenomenon interference
(d) It is propagated as longitudinal wave

(2) The waves that require a material medium for their propagation are called
(a) matter waves
(b) electromagnetic waves
(c) carrier waves
(d) mechanical waves

(3) Which organ produce a better quality of sound
(a) closed organ pipe
(b) open organ pipe
(c) both a and b
(d) none of these

(4) When two identical traveling waves are superimposed, the velocity of the resultant wave
(a) decreases
(b) increases
(c) remains unchanged
(d) becomes zero

(5) In vibrating cord the points where the amplitude is maximum, are called
(a) antinodes
(b) nodes
(c) troughs
(d) crests

(6) Echo is the phenomenon of
(a) interference of sound
(b) reflection of sound
(c) refraction of sound
(d) none of these

(7) The phase difference between particles being on either side of a node
(a) π
(b) π/2
(c) 2π
(d) π/4

$\lambda/2$

(8) If stretching force T of wire increases, then its frequency
(a) decreases
(b) increases
(c) remains the same
(d) any of above

$f = \frac{1}{2l}\sqrt{\frac{T}{m}}$

(9) A stationary wave is set up in the air column of a closed pipe. At the closes end of the pipe
(a) always an node is formed
(b) always an antinode is formed
(c) neither node nor antinode is formed
(d) sometimes a node and sometimes an antinode is formed

(10) It is possible to distinguish between transverse and longitudinal waves form the property of
(a) refraction
(b) polarization
(c) interference
(d) diffraction

longitudinal waves can't be polarize

(11) According to Newton sound travel in air under the conditions of
(a) adiabatic
(b) isothermal
(c) isobaric
(d) isochoric

(12) Beats are as a result of
(a) Diffraction
(b) Constructive interference
(c) Destructive interference
(d) Alternate constructive and destructive interference

(13) Velocity of sound in vacuum is
(a) 332 ms-1 (b) 320 ms-1
(c) Zero (d) 224 ms^{-1}

(14) Increase in velocity of sound in the air for 1°C rise in temperature is
(a) 1.61 ms-1 (b) 61.0 ms-1
(c) 0.61 ms-1 (d) 2.00ms^{-1}

(15) Energy is not transferred by
(a) Longitudinal wave (b) Transverse waves
(c) Stationary waves (d) Electromagnetic waves

(16) On loading the prong of a tuning form with wax, its frequency
(a) increases (b) decreases
(c) remains unchanged (d) may increase or decrease

(17) The velocity of sound in air would become double than its velocity at 0°C at temperature
(a) 313°C (b) 586°C
(c) 819°C (d) 1172°C

$2 = \frac{v}{v_0} = \sqrt{\frac{T}{T_0}}$
$(2)^2$
273×4
1092

(18) At antinodes
(a) Pressure is minimum and velocity is minimum
(b) Pressure is minimum and velocity is maximum
(c) Pressure is maximum and velocity is maximum
(d) None of these

(19) Ultrasonic have
(a) frequency in the audible range (b) frequency is greater than 20 kHz
(c) frequency lower than 20 Hz (d) all of above

(20) The periodic alternation of sound between maximum and minimum loudness are called
(a) silence zone (b) interference
(c) beats (d) resonance

(21) The number of beats produced per second is equal to
(a) the sum of the frequencies of two tuning forks
(b) the difference of the frequencies of two tuning forks
(c) the ratio of the frequencies of two tuning forks
(d) the frequency of either of the two tuning forks

(22) Beats are the results of
(a) diffraction of sound waves
(b) constructive and destructive interference
(c) polarization
(d) destructive interference

(23) Silence zone takes place due to
(a) constructive interference (b) destructive interference
(c) beats (d) resonance

(24) Doppler effect applies to
(a) sound wave only (b) light wave only
(c) both sound and light waves (d) neither sound nor light wave

(25) When the source of sound moves away form a stationary listener, then ________ occurs.

(a) an apparent increase in frequency

(b) an apparent decrease in frequency

(c) an apparent decrease in wavelength

(d) no apparent change in frequency .

$f = \frac{v}{v+u_s}$

(26) A simple pendulum has a bob of mass 'm' and its frequency is 'f'. If we replaced the bob with a heavier one, say of '2m', then what will be its new frequency?

(a) 1/4f

(b) 1/2f

(c) f

(d) 2f

(27) Which one is the correct relation for fundamental frequency of open and closed pipe?

(a) $f_{open} = 2\ f_{closed}$

(b) $f_{closed} = 2f_{open}$

(c) $f_{open} = \ f_{closed}$

(d) $f_{open} = 1/\ f_{closed}$

$l = \frac{\lambda}{4}$ $\lambda = 4l$

$f_c = \frac{v}{4l}$

$f_o = \frac{v}{2l}$

(28) In open organ pipe

(a) only even harmonics are present

(b) only odd harmonics are present

(c) both even and odd harmonics are present

(d) selected harmonics are present

(29) Which one is the correct relation?

(a) $V_{Newton} = V_{Laplace}$

(b) $V_{Newton} = \gamma V_{Laplace}$

(c) $V_{Newton} = \sqrt{\gamma}\ \ V_{Laplace}$

[✓ (d) $V_{Laplace} = \sqrt{\gamma}\ \ V_{Newton}$]

(30) If the temperature increases the frequency of tuning fork

(a) increases

[✓ (b) decreases]

(c) no change

(d) none of these

$v = \sqrt{\frac{P}{\rho}}$

(31) The particles in the wave separated through ________ multiple of λ are out of phase to each other

(a) (n)

(b) (n+1)

(c) [n+1/2)

(d) both (a) and (c)

(32) Waves produced at the surface of water by a pencil executing periodic motion if held vertically at a frequency of 50Hz are

(a) Longitudinal

(b) Transverse

(c) Periodic

(d) Both (b) and (c)

(33) Newton formula estimated the speed of sound

(a) 281m/sec

(b) 333m/sec

(c) 340m/sec

(d) all of the above

(34) Laplace found that the alternate compressions and rarefactions produced in sound waves follows

(a) isothermal law

(b) adiabatic law

(c) isochoric law

(d) all of the above

(35) For destructive interference of sound waves the path difference between two interfering sounds should be

$(2n+1)\frac{\lambda}{2}$

(a) nλ

(b) (n+1/2)λ

(c) some time nλ and some times (n+1/2)λ

(d) none of these

(36) The speed of sound in hydrogen is ____________time than that in oxygen

(a) Two times
(b) Three times
(c) Four time
(d) Six time

(37) The beats frequency (sensible) for a human ear is

(a) 4Hz
(b) 10Hz
(c) 12Hz
(d) 16Hz

(38) The speed of stationary waves in a stretched string are independent of

(a) Number of loops
(b) Tension in the string
(c) Point where string is plucked
(d) Both (a) and (c)

(39) If two waves of amplitude of 'x' produce a resultant wave of amplitude 'x' then phase difference between them will be

(a) 60^0
(b) 120^0
(c) 180^0
(d) 0^0

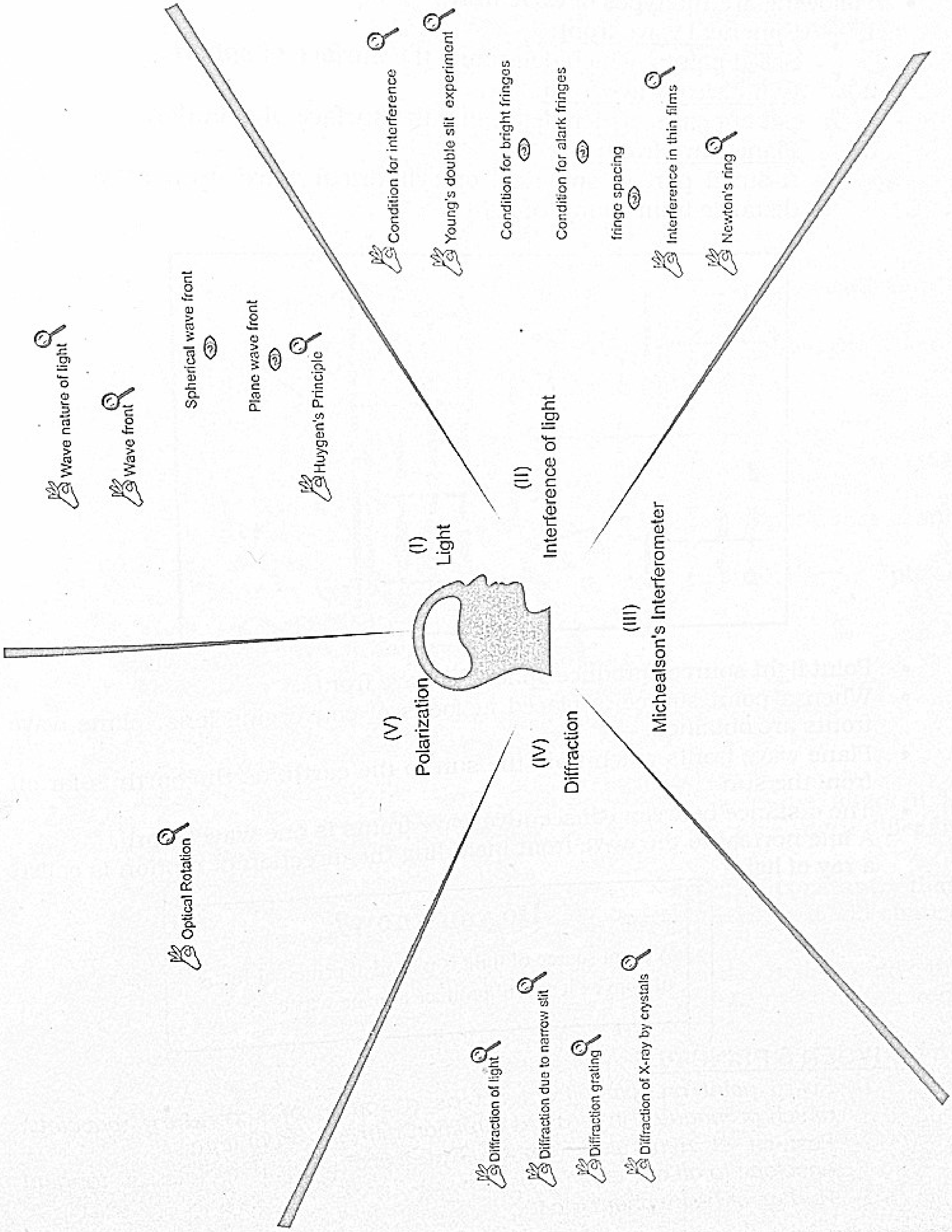
(40) Which phenomena can be applied to estimate the velocity of star with respect to earth

(a) Doppler's effect
(b) Interference of waves
(c) Beats phenomena
(d) All of these

TOP Study

Chapter 9

PHYSICAL OPTICS


(I) Light
Wave nature of light
Wave front
Spherical wave front
Plane wave front
Huygen's Principle
(II) Interference of light
Condition for interference
Young's double slit experiment
Condition for bright fringes
Condition for dark fringes
fringe spacing
Interference in thin films
Newton's ring
(III) Michealson's Interferometer
(IV) Diffraction
Diffraction of light
Diffraction due to narrow slit
Diffraction grating
Diffraction of X-ray by crystals
(V) Polarization
Optical Rotation

Chapter 9

Physical Optics

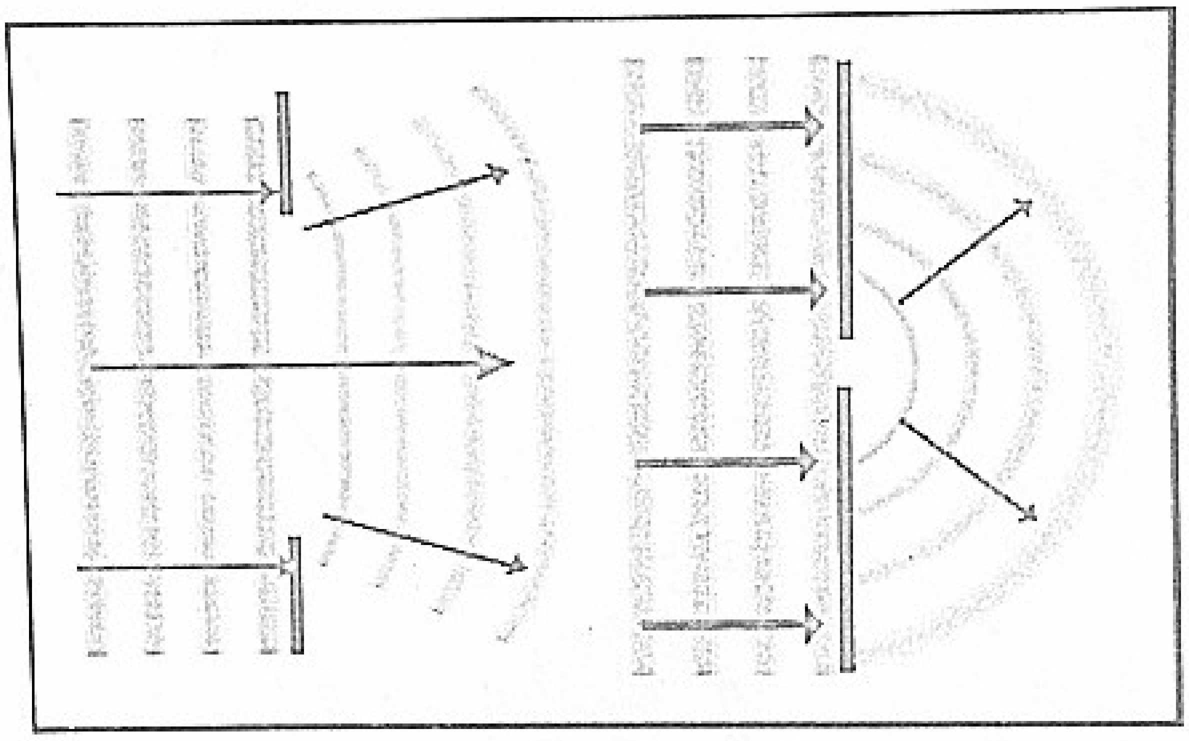
WAVE FRONT AND RAYS

- *Wave front* is a locus of points which have same phase of vibrations.
- Following are the types of wave front;

1- Spherical wave front:
Set of points, which determine the surface of sphere.

2- Cylindrical wave front:
Set of points, which determine the surface of cylinder.

3- Plane wave front:
A small part of spherical or cylindrical wave front at very large distance from source of light



- Point light sources produce spherical wave fronts.
- When a point source is placed at focus of converging lens, plane wave fronts are obtained.
- Plane wave fronts reach from the sun to the earth, as the earth is far off from the sun.
- The distance between consecutive wave fronts is one wavelength.
A line normal to the wave front including the direction of motion is called a ray of light.

Do you know?

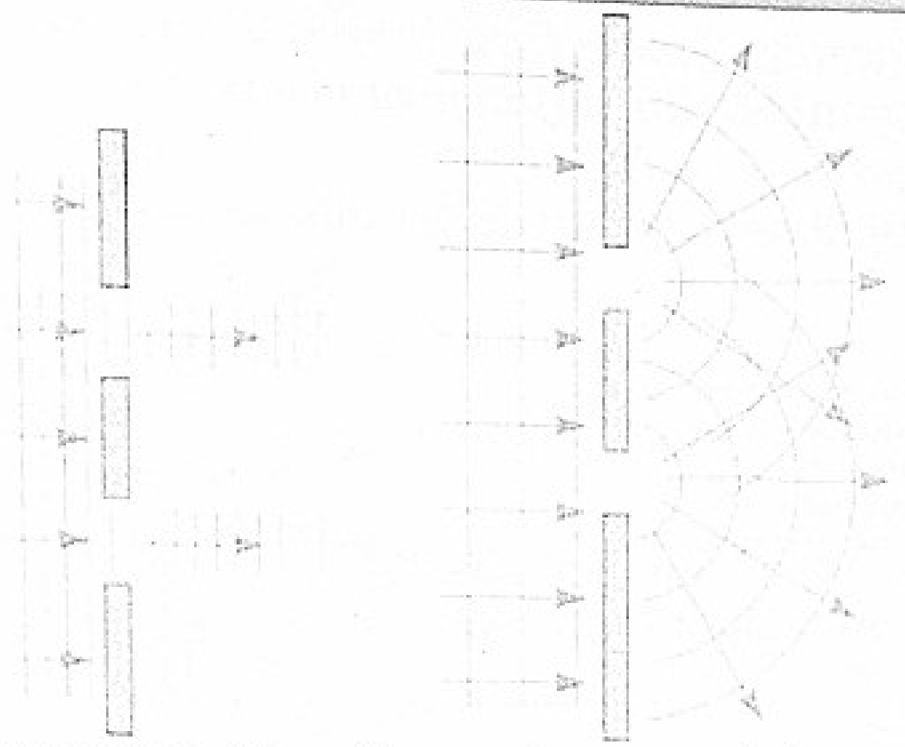
A point source of light is placed at principal focus of convex lens will produce a plane wave.

HUYGEN'S PRINCIPLE

1- *Every point on wave front act as a source of secondary wavelets, which propagates in forward direction with speed of light.*

2- *Position of new wave front of all secondary wavelets is tangent envelope to all of them.*

3- *Radius of hemisphere* = $c\Delta t$



- There is an infinite number of secondary wavelets present on wave front.
- Light ray is associated with direction of flow of light energy.
- *In a homogeneous medium, the energy of wave is transmitted equal in all sides and wave front remains spherical for long distance*

INTERFERENCE OF LIGHT

Interference is a superposition of two light waves of same frequency and same amplitude propagating in same medium along same direction very close to each other.

- *For constructive interference*, light wave reaches a point in phase and their path difference = n λ
- *For destructive interference*, light wave reaches a point in out of phase and their path difference = (2n+1)λ/2
- ***Conditions for interference of light***
  1- Monochromatic (Having single wave length)
  2- Coherence (Having constant phase difference)
  3- Same direction
  4- Same medium
  5- Very Close to each other.
- There is no perfect monochromatic source, but by using filters it is possible to produce a source that gives light whose wavelength differ by $\pm 5\times10^{-10}$ m
- If phase difference between two waves remains constant, then interference pattern will be stationary on screen otherwise it will change continuously.
- *For two ordinary sources, no interference pattern is obtained, because the phase changes rapidly and irregularly* (that's why to get two coherent waves a single source of light is split into two).
- *Optical path* is equal to product of refractive index of medium and distance covered in air.

  Optical path = nd

  where 'n' is refractive index and 'd' is path in air.

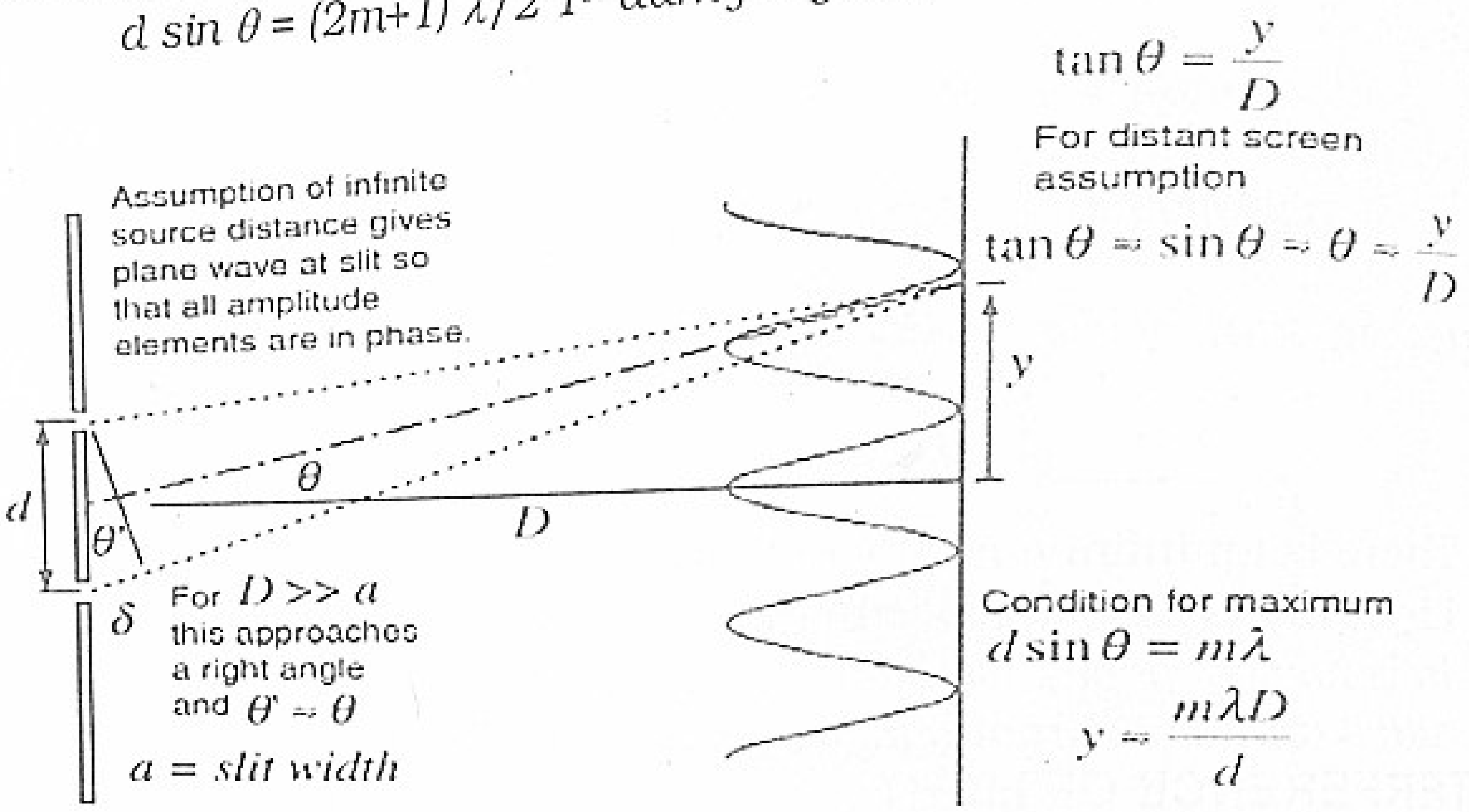
YOUNG'S DOUBLE SLIT EXPERIMENT

- *Path difference* = *d sin θ*

- *For bright fringes;*

  $d \sin\theta = m\lambda$ *1^{st} bright fringe at $m = 0$*
- *For dark fringes;*

  $d \sin\theta = (2m+1)\lambda/2$ *1^{st} dark fringe at $m = 0$*


$\tan\theta = \frac{y}{D}$
For distant screen assumption
$\tan\theta \approx \sin\theta \approx \theta \approx \frac{y}{D}$
Assumption of infinite source distance gives plane wave at slit so that all amplitude elements are in phase.
y
θ
d
θ'
D
δ
For $D >> a$ this approaches a right angle and $\theta' \approx \theta$
a = slit width
Condition for maximum
$d\sin\theta = m\lambda$
$y \approx \frac{m\lambda D}{d}$

- $y_m = m\lambda D/d$ *(position of mth bright fringe)*
- $y_m = (2m+1)\lambda D/2d$ *(position of mth dark fringe)*
- $\lambda = y_m d/mD$ *(wavelength from bright fringe)*
- $\lambda = 2y_mD/(2m+1)d$ *(wavelength from dark fringes)*
- Distance between centers of two consecutive dark fringes or bright fringes is called *fringe width.*

  F.W = $\lambda D/d$ (applicable both for bright or dark fringes)
- ***Suggestions to widen the interference fringes***

  F.W. $\propto \lambda$ (to increase λ)
  F.W $\propto D$ (to increase D)
  F.W $\propto 1/d$ (to decrease d)

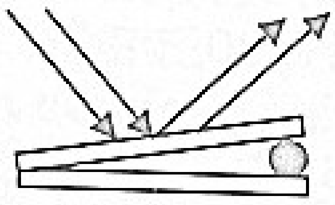
INTERFERENCE IN DIFFERENT TYPES OF THE FILMS

- Thin film of refracting medium having thickness comparable to the wavelength of light rays e.g.
  1- Oil film on water
  2- Soap film
  3- Air film
- *When exposed to white light,* thin film produces colorful pattern due to interference.
- *When exposed to monochromatic light,* only bright and dark fringes are obtained
- ***Classification of thin films***

  1- Uniform or parallel thin films:
  Whose thickness is uniform? It gives straight interference pattern.

  2- Wedge-shaped films:

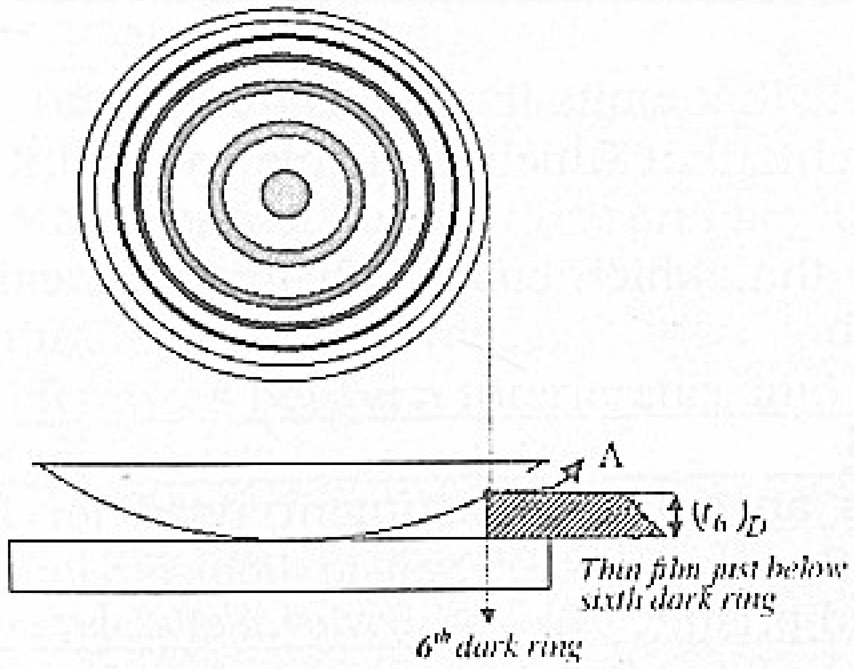
Whose thickness is zero at one end and then increases uniformly. *Its interference pattern comprises a set of parallel fringes all parallel to the edge of wedge.*



- Wedge shaped films can be obtained using a spacer between the two slides of glass.
- *The thinnest part of wedge film shaped is always dark, due to additional path difference of $\lambda/2$, caused by phase reversal, at denser medium.*

NEWTON'S RINGS

- Newton's rings are practical study of interference in wedge shaped thin films.



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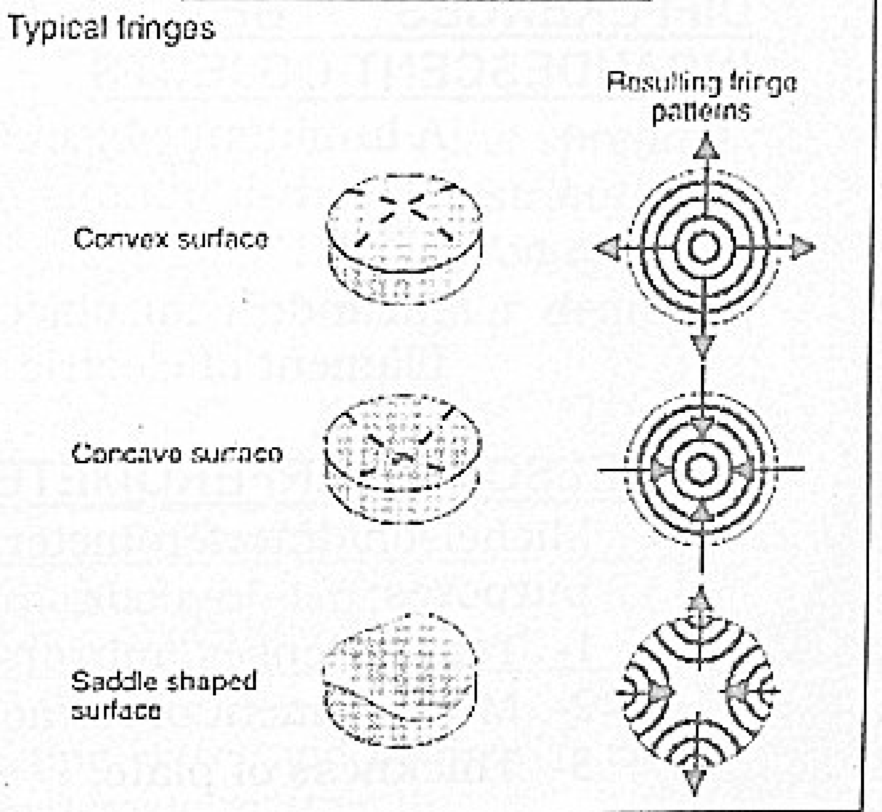


1 When sodium light is incident on the plano convex lens system, light rays reflect from upper and lower layers of the air present between lens and the glass plate. The sodium light source is almost monochromatic.

There is no phase change at the lens-air surface, because the wave if going from a higher to a lower refraction index medium. At the air-plate surface, however, there is a phase shift of p with the reflection from a medium of higher refractive index.

Waves reflected from these two surfaces interfere, forming bright bands where the path length in air produces two waves in phase and dark bands where the waves are in antiphase.

The centre of the pattern is black. There is no reflection because there is no air gap here.

2 The thickness of the thin film is equal to the thickness of the airfilm adjacent to it.

3 The fringes are circular as the locus of points of equal thickness of air is a circle.

- *Conditions for interference are reversed for Newton's rings as;*

  Path difference = mλ (for dark ring)

  Path difference = (2m+1)λ/2 (for bright ring)

  This is due to **phase reversal by 180°** and extra path difference of λ/2.
- *Point of contact is always dark due to* ***phase reversal*** *at point of contact.*

PRIMARY AND SECONDARY COLOURS

Red, green and blue colours are called *primary* colours. *Complementary* colours of white light are those two colours, whose combined effect is to produce white light on eye. They are;

1- Red and blue - green
2- Yellow and blue - violet
3- Green and purple (mixture of red and blue)

If two primary colours of white light are mixed, we get complementary colours. e.g. red and green primary colours are mixed, we get yellow, which is complementary colours of blue-violet.

DIFFERENCES BETWEEN LUMINOUS, NON-LUMINOUS AND INCANDESCENT OBJECTS

→ A luminous object is one that emits its own light e.g. sun

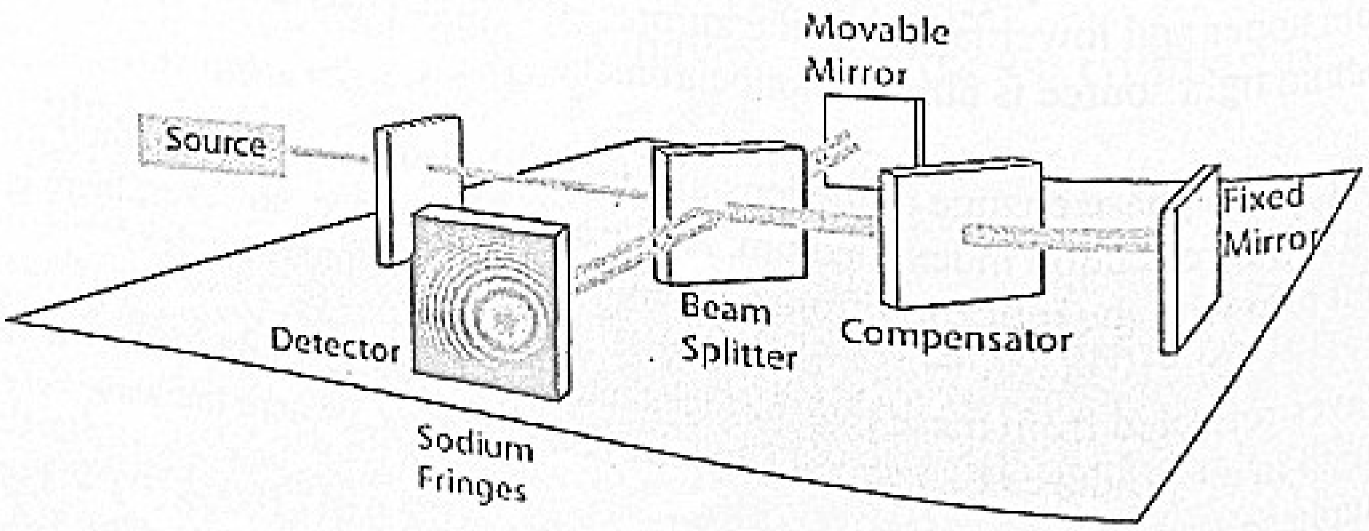
→ An non-luminous object is that which is visible by light it reflects. e.g. moon

→ Incandescent object is that which emits light due to heating, e.g. filament of electric bulb.

MICHELSON INTERFEROMETERS

- Michelson interferometers is an optical instrument used for following purposes;

  1- Testing lenses, mirrors and prisms.
  2- Measurement of refractive indices.
  3- Thickness of plate.



- *Interferometers are based upon the principle of division of wave front*
- Michelson's interferometer consists of following essential parts;

  1- Diffused source of monochromatic light.
  2- Beam splitter (semi-silvered glass).

3- Plane mirrors held ⊥ to each other, one is fixed and the other is movable.
4- Micrometer (it is attached to movables mirror)
5- Compensator (glass plate equal in thickness to beams splitter)
6- Telescope (to observe interference fringes)

- *If mirror is moved by a distance of $\lambda/2$, with **dark fringe in view**, then fringe of same kind is observed because **total path difference is λ**.*
- *If mirror is moved by distance of $\lambda/4$, **then alternatively, dark and** bright fringes can be observed because **total path difference is $\lambda/2$**.*
- If mirror is moved through distance p, then 'm' fringes pass before eye.

  $$p = m\lambda/2$$

- Interferometer can be used:
  1- To determine refractive index
  2- To test planes of glass slabs and lenses
  3- To determine wavelength of light

DIFFRACTION OF LIGHT

Bending of light around edges of a slit is called diffraction or the spreading of light waves into geometrical shadow of an obstacle and redistribution of light intensity resulting in dark and bright fringes is called diffraction of light.

- The smaller is size of diffracting object (obstacle), the higher degree of diffraction is observed.
- Differences between interference and diffraction

Interference	***Diffraction***
1- Superposition of few secondary wavelets is involved.	1- Superposition of large number of secondary wavelets is involved.
2- Interference fringes are equal in size.	2- Diffraction fringes wide near diffracting object and become small as one move away from it.
3- Interference fringes are equally spaced.	3- Diffraction fringes become narrow as distance from diffracting object increases.
4- Points of destructive interference are perfectly dark.	4- Points of minimum intensity are not perfectly dark.

DIFFRACTION DUE TO NARROW SLIT

- Diffraction due to a narrow slit has central maxima and alternative minima and maxima on either side.
- Condition for mth order minima on either side of center is given by

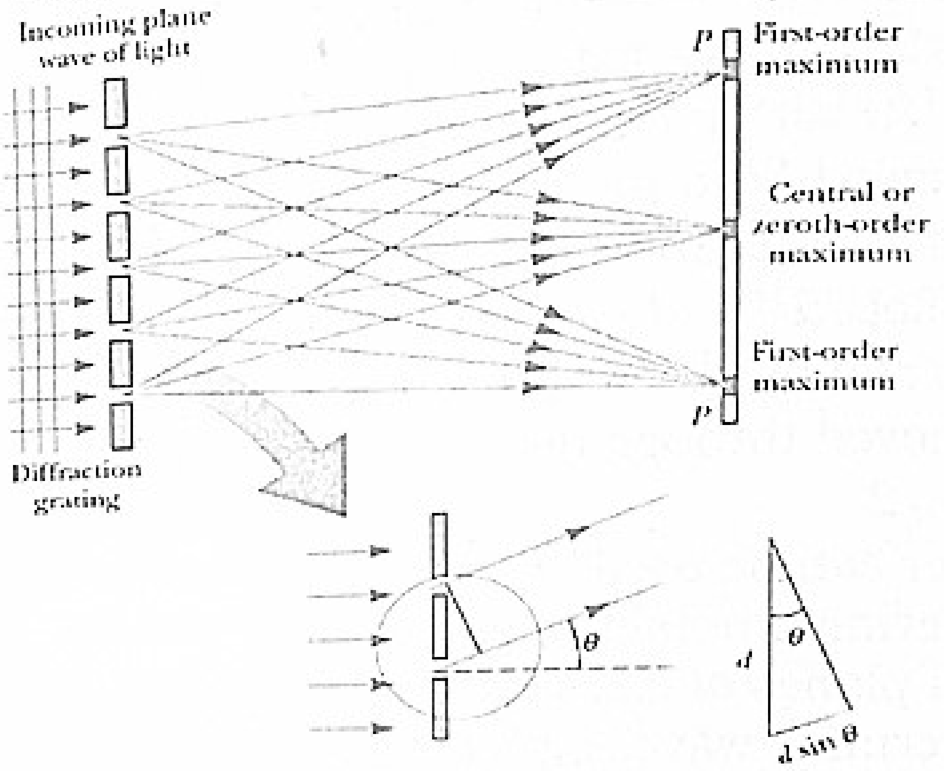
$$D \sin\theta = m\lambda$$

where $m = 1,2,3,\ldots\ldots$

DIFFRACTION GRATING

Diffraction grating is a multi-slit arrangement of parallel and equally spaced slits.

Suppose monochromatic light is directed at the grating parallel to its axis as shown. Let the distance between successive slits be d.

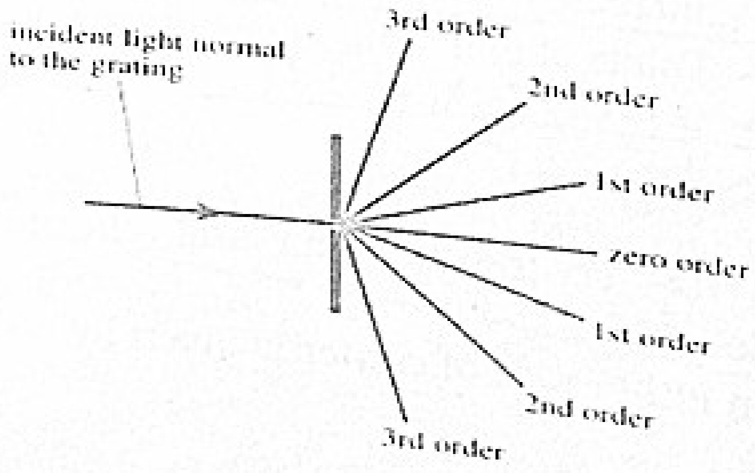


The diffraction pattern on the screen is the result of the combined effects of diffraction and interference. Each slit causes diffraction, and the diffracted beams in turn interfere with one another to produce the pattern. The path difference between waves from any two adjacent slits can be found by dropping a perpendicular line between the parallel waves. By geometry, this path difference is d sin θ . If the path difference equals one wavelength or some integral multiple of a wavelength, waves from all slits will be in phase and a bright line will be observed at that point. Therefore, the condition for maxima in the interference pattern at the angle θ is

$$d \sin\theta = m\lambda$$

where n = 0,1,2,3…..

Because d is very small for diffraction grating, a beam of monochromatic light passing through a diffraction grating is splitted into very narrow maxima(bright fringes) at large angles θ.



Do you know?

Practically a diffraction grating is a piece of glass with 400 → 5000 lines per cm.

- Lines are opaque while separation between them are transparent, so space between two engraved lines behave as slits.
- Distance between two slits is called *grating element.*

  $$d = 1/N$$

  where 'N' is the number of lines in one unit length.
- Grating equation is given as

  $$d \sin\theta = m\lambda$$

  where 'm' is called the *order of diffraction* pattern.
- For while light, we see colored fringes.
- *Resolving power of grating* is its ability to separate two wavelengths of light in given order of their spectrum.

  Resolving Power = $\lambda/\Delta\lambda = N \times m$

  N = number of lines ruled on grating

  m = order of diffraction

DIFFRACTION OF X-RAYS BY CRYSTALS

- *Bragg's law* is given as

  $$2 d \sin 0 = m\lambda$$

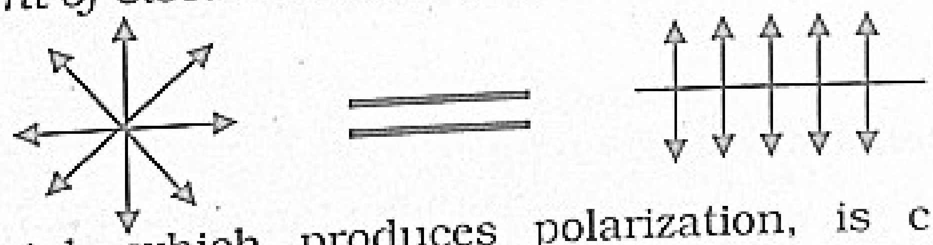
  Where'd' is called lattice spacing and θ is called angle of diffraction.
- Solid crystal behaves as very good natural diffraction gratings and incident ultraviolet light is diffracted from layers of atoms.
- Inter atomic layer distance is called lattice constant.
- In 1913, Max Von Laue suggested that since atomic layers in solid NaCl have layer separation of **10^{-10} m**, therefore, **X-rays can be diffracted.**
- Max von laue pattern on film is in the form dark spots/bright spots.
- Analysis of the relative intensity of dark/bright spots gives rise to crystal structure of solid.

Do you know?

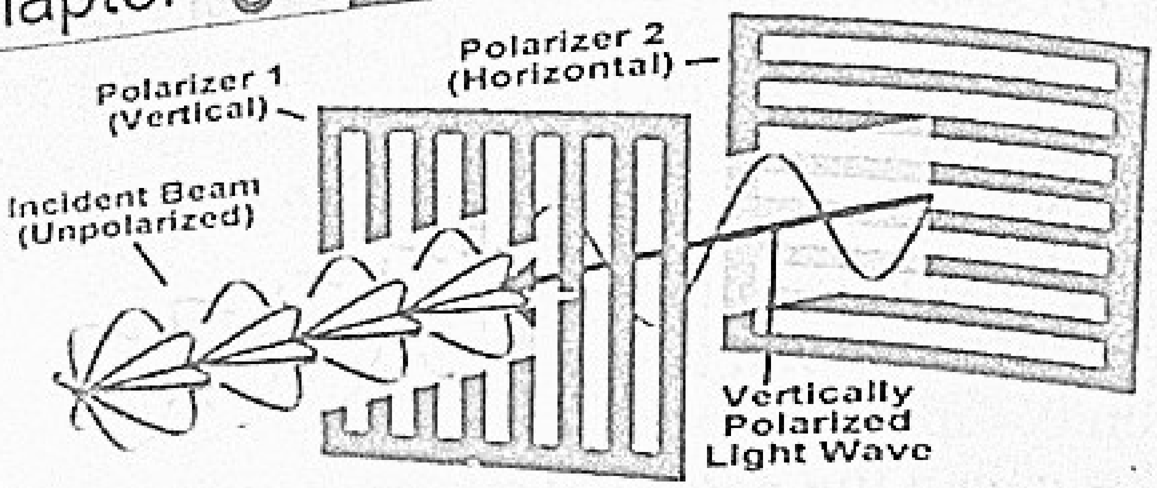
Diffraction proves that wavelength of light is smaller than that of sound

POLARIZATION

Confinement of electric vectors of light into one plane is called polarization.



- The material, which produces polarization, is called *polarizor.* e.g. tourmaline crystal is a polarizer.



- *Polariod* (polarizer) absorbs all magnetic vectors as well as randomly oriented electric vectors leaving only those electric vectors, which are in one plane.
- Tourmaline crystal has internal molecular structure such that their interaction with incident light is to:
  1- absorb all magnetic vectors
  2- put (confine) all electric vector in one plane.
- Polarization is possible only in e.m waves because their electric and magnetic vectors are ⊥ to each other as well as well to direction of propagation. Thus, ***polarization has established that light is a transverse wave.***
- *Analyser is used to test plane polarization.*
- Plane determined by direction of propagation and polarized electric vectors of light is called plane of polarization.
- Different methods for producing plane polarized light are given below;
  1- Polarizer (e.g. tourmaline crystal, calcite, crystal)
  2- Polarization by reflection.
- ***Uses of polarized light***
  1- Determination of optically active substance e.g. sugar in blood & urine.
  2- Curtainless window.
  3- To enhance effect of clouds & sky in photograph.
  4- Headlights of vehicles to control the glare in night driving.

PRACTICE EXERCISE

30 min Time Yourself

(1) Optical active crystals rotates the
(a) vibrating plane
(b) polarization plane
(c) diffraction plane
(d) interference plane

(2) Which is not optically active substance?
(a) sugar
(b) tartaric acid
(c) water
(d) sodium chlorate

(3) In double slit experiment, we observe
(a) interference fringes only
(b) diffraction fringes only
(c) both interference and diffraction fringes
(d) polarized fringes

(4) When light incident normally on thin film, the path difference depends upon
(a) thickness of the film only
(b) nature of the film only
(c) angle of incidence only
(d) all thickness, nature and angle of incidence

(5) Which one of the following properties of light does not change with the nature of the medium?
(a) velocity
(b) wavelength
(c) amplitude
(d) Frequency

(6) Huygen wave theory cannot explain
(a) diffraction
(b) interference
(c) polarization
(d) photoelectric effect

(7) Photoelectric effect was explained by
(a) Hertz
(b) Fresnel
(c) Einstein
(d) Plank

(8) According to Einstein, light travels form one place to another in the form of
(a) waves
(b) particles
(c) photons
(d) it was not his discovery

(9) Longitudinal waves do not exhibit
(a) reflection
(b) refraction
(c) diffraction
(d) polarization

(10) signal from the T.V remote control travels
(a) with speed of sound
(b) with the speed of light
(c) with the speed of ultrasonic
(d) with the speed of supersonic

(11) A point source of light placed in a homogeneous medium gives rise to
(a) a cylindrical wave front
(b) an elliptical wave front
(c) a spherical wave front
(d) a plane wave front

(12) The locus of all points in a medium having the same phase of vibration is called
(a) crest (b) trough
(c) wavelength (d) wave front

(13) Which one of the following is nearly monochromatic light?
(a) light form fluorescent tube (b) light form mercury lamp
(c) light form sodium lamp (d) light form simple lamp

(14) Two sources of light are coherent if they emit rays of
(a) same wavelength
(b) same amplitude of vibration
(c) same wave length with constant phase difference
(d) same amplitude and wavelength

(15) When crest of one wave falls over the trough of the other wave, this phenomenon is known as
(a) polarization (b) constructive interference
(c) destructive interference (d) diffraction

(16) In Young's double slit experiment, the fringe spacing is equal to
(a) $d\lambda D$ (b) $2\lambda d/D$
(c) $\lambda D/d$ (d) $\lambda d/D$

(17) In Young double slit experiment, if white light is used
(a) alternate dark and bright fringes will be seen
(b) coloured fringes will be seen
(c) no interference fringes will be seen
(d) impossible to predict

(18) The velocity of light was determined accurately by
(a) Newton (b) Michelson
(c) Huygen (d) Young

(19) The condition for constructive interference of two coherent beams is that the path difference should be
(a) integral multiple of $\lambda/2$ (b) integral multiple of λ
(c) odd integral multiple of $\lambda/2$ (d) even integral multiple of λ

(20) In an interference pattern
(a) bright fringes are wider than dark fringes
(b) dark fringes are wider than bright fringe
(c) both dark and bright fringes are of equal width
(d) central fringes are brighter than the outer fringes

(21) In Young's double slit experiment, the separation between the slit is halved and distance the between the slit and screen is doubled. The fringe width is
(a) remain same (b) double
(c) half (d) quadrupled

(22) The blue colour of the sky is due to
(a) diffraction (b) reflection
(c) polarization (d) scattering

(23) A light ray traveling form rarer to denser medium suffers a phase change of
(a) 60° (b) 90°
(c) 180° (d) 45°

(24) When one mirror of a Michelson Interferometer is moved a distance of 0.5 mm, we observe 2000 fringes. What will be wavelength of light used?
(a) 5000 nm
(b) 5000 A°
(c) 500m
(d) 2000μm

(25) Diffraction effect is
(a) more for a round edge
(b) less for a round edge
(c) more for a sharp edge
(d) less for a sharp edge.

(26) The wavelength of X- rays is of the order of
(a) 10A°
(b) 1000 A°
(c) 1A°
(d) 100 A°

(27) Wavelength of X- rays falling at glancing angle of 30° on a crystal with atomic spacing $2x10^{-10}$ for the fist order diffraction is
(a) $4x10^{-10}$m
(b) $2x10^{-10}$m
(c) $0.02x10^{-10}$m
(d) $20x10^{-10}$m

(28) A diffraction grating has 500 lines per mm. Its slit spacing or grating element will be equal to
(a) 500 mm
(b) $5x10^{-3}$ mm
(c) $2x10^{-5}$ mm
(d) $2x10^{-3}$mm

(29) In a plane polarized light electric vibration are
(a) in all direction
(b) in two mutually perpendicular directions
(c) taking place perpendicular to the direction of propagation of light
(d) no vibration at all.

(30) Light on passing through a Polaroid is
(a) plane polarized
(b) un-polarized
(c) circularly polarized
(d) elliptically polarized

(31) Which one of the following cannot be polarized?
(a) radio waves
(b) ultraviolet rays
(c) X-rays
(d) sound waves

(32) Diffraction fringes are
(a) equally spaced
(b) distance between them increases
(c) distance between them not remain constant
(d) they are adjacent with no space in between

(33) In monochromatic red light, a blue book will probably appear to be
(a) black
(b) purple
(c) green
(d) no scientific reasoning available

(34) A polarizer is used to
(a) Reduce the intensity of light
(b) produce unpolarized light
(c) increase intensity of light
(d) produce polarized light

(35) In double slit experiment, if one of the two slit is covered then
(a) no interference fringes are observed
(b) no diffraction fringes are observed
(c) no fringes observed
(d) interference pattern not disturbed

(36) __________ gives the definition of metre in terms of wavelength of red cadmium light

(a) Newton
(b) Einstein
(c) Michelson
(d) Galileo

(37) In Michelson interferometer to switch the fringe from bright to dark the mirror should be displaced through

(a) $\lambda/(b)$
(b) $\lambda/3$
(c) $\lambda/6$
(d) $\lambda/4$

(38) In the shadow of a ball the central portion appears bright that happens due to

(a) Interference
(b) Diffraction
(c) Polarization
(d) Refraction

(39) Which experiment shows that wavelength of light is smaller than that of sound

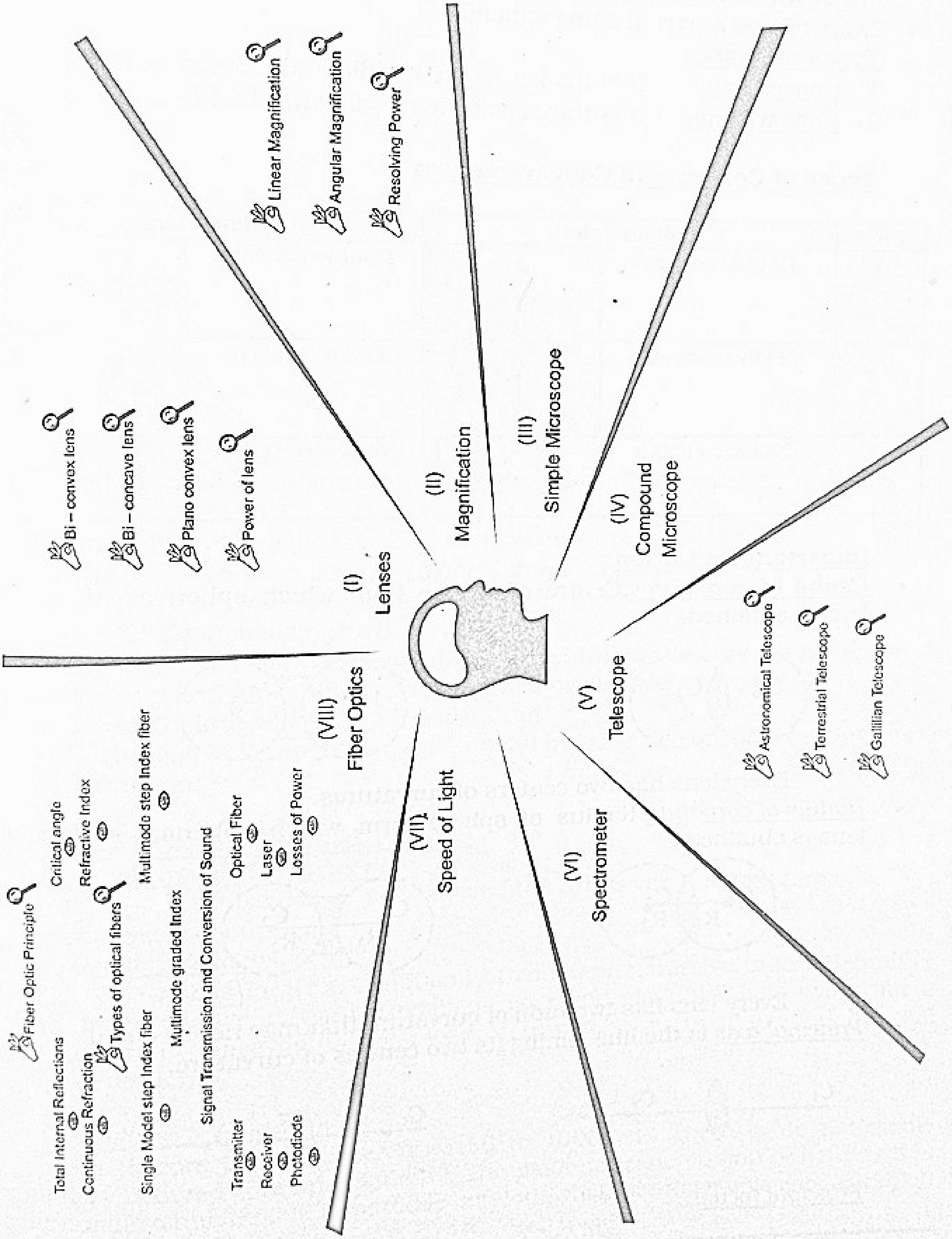
(a) Diffraction
(b) Polarization
(c) Interference
(d) Reflection

(40) Crystals of a material can behave as

(a) Convex lens
(b) Interferometer
(c) Diffraction grating
(d) Concave

Chapter 10

OPTICAL INSTRUMENTS



Chapter 10 Optical Instruments

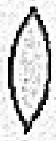
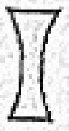
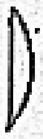
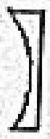
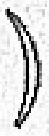
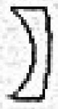
LENS

- Lens is a piece of transparent medium bounded by two surfaces at least one of which is curved.
- Every lens is a part of some sphere.

Types of Lenses

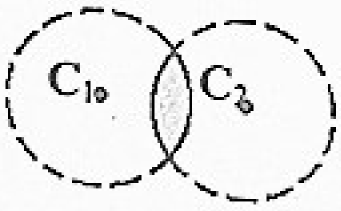
1- Convex lens: It is thicker at the middle and thinner at the edges.
2- Concave lens: It is thinner at the middle and thicker at the edges.

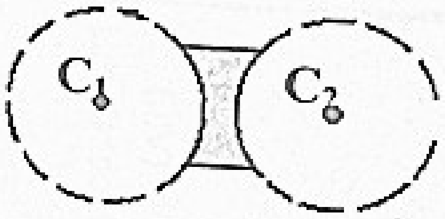
Types of Convex and Concave Lenses

SR #	Convex lens		Concave lens	
1	Double convex		Double concave	
2	Plano convex		Plano concave	
3	Concavo convex		Convexo concave	

Important Definitions

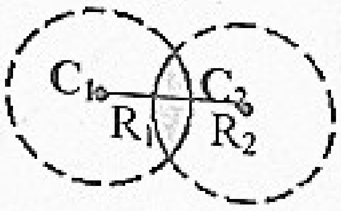
- *Centre of curvatures*: Centre of sphere from which spherical surface of lens is obtained.

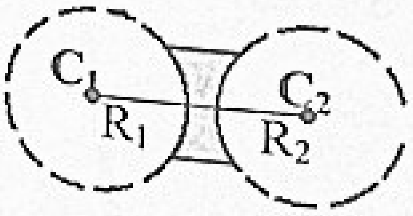




Every lens has two centers of curvatures.

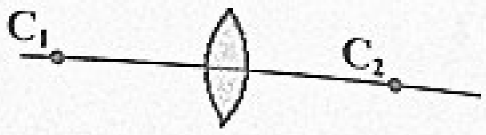
- *Radius of curvature*: Radius of sphere form which spherical surface of lens is obtained.

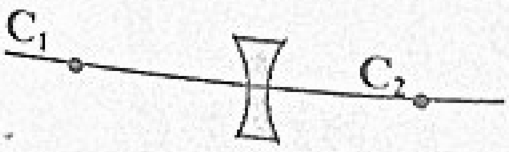




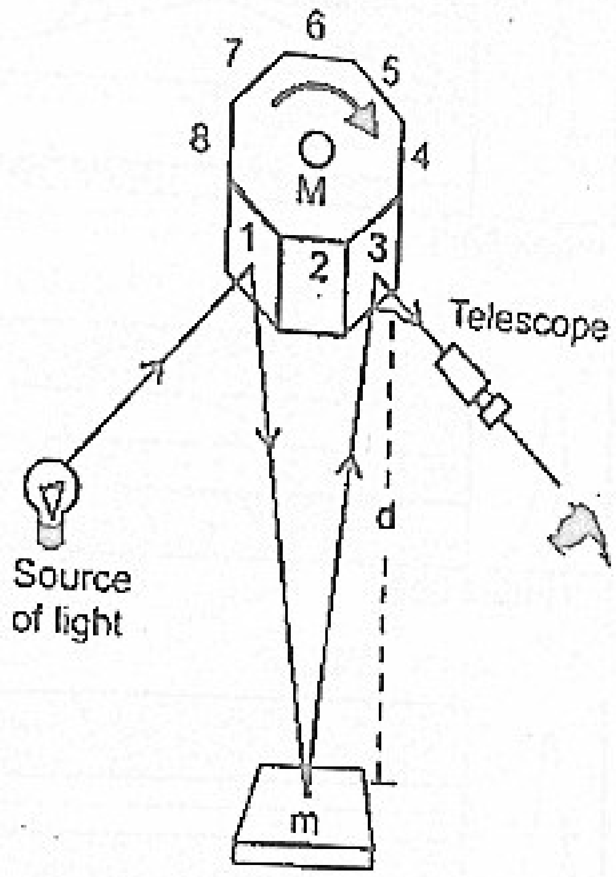
Every lens has two radii of curvature that may not be equal.

- *Principal axis* is the line joining its two centres of curvature.





- *Principal focus*:



INTRODUCTION TO FIBRE OPTICS

- *Graham Bell invented* ***photo phone*** **to** transmit voice massage via beam of light.
- In optical fiber, light is used as a **transmission carrier wave.**
- *The principle of transmitting signals through optical fibre is*
  - *(1) Total internal reflection*
  - *(2) Continuous refraction*
- *Optical fibre* is a fine glass rod having central portion of high refractive index called core, which is surrounded by glass layer having low refractive index that is called **cladding.**
- Light passes through core due to total internal reflection or continuous refraction.
-

CLASFICATION OF OPTICAL FIBRES

Single mode step index fibre

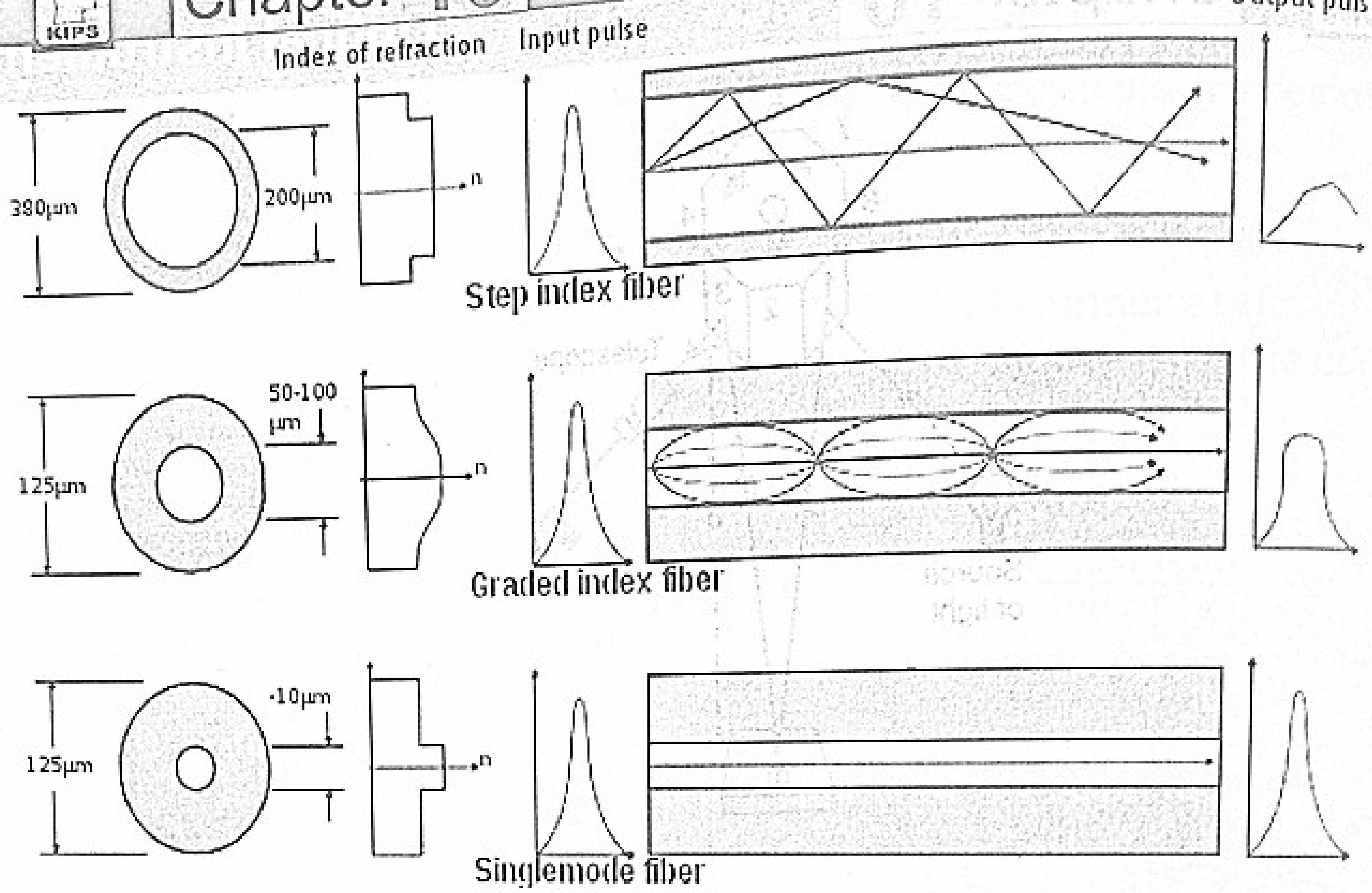
It is also called mono mode fibre & has very **narrow** core of diameter about 5 μm.

Multimode step index fibre

It has larger core (50μm) of constant refractive index. Refractive index change at the boundary of core and cladding. It is useful for a short distance only. The mode of transmission in it is total internal reflection.

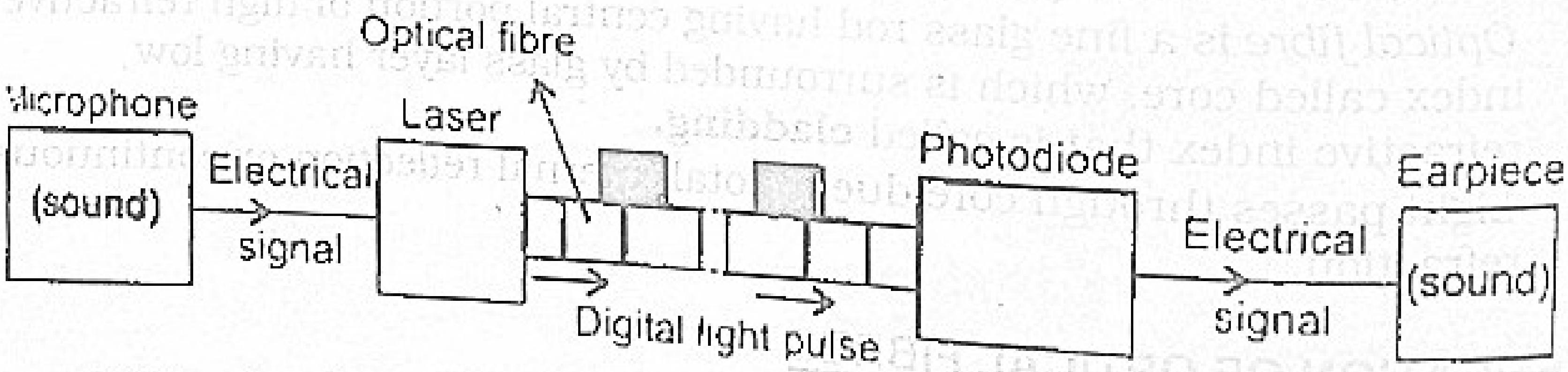
Multimode graded index fibre

In it, core has diameter from 50 to 1000 μm. There is no noticeable boundary between core and cladding. The mode of transmission of light in it is continuous refraction. It is suitable for long distance transmission in which white light is used.



SIGNAL COMMUNICATION

- Fibre optic communication system consists of three parts
  - (i) *Transmitter:* To convert electrical signals to light signals
  - (ii) *Optical Fibre:* To guide the light signals
  - (iii) *Receiver:* To capture the light signal and convert them to electric signals.



- Light signals travel through fibre in `on` and `off`. A light pulse **represents, 1 and** absence of light **represents 'O'**
- <u>*Advantages of communication through optical fibre*</u>
  - (i) Light signals in glass travels faster then electrical signals in copper cable
  - (ii) More massages per cable length. (High signal strength)
  - (iii) Clear sound is received

LOSSES OF POWER

- Power is lost in optical fibre is due to scattering of light from impurities atoms in glass
- Due to dispersion of light, signal also get errors
- *Errors due to dispersion are reduced by using graded index fibre*
- *Repeaters* are used at suitable distance to overcome the power loss due to scattering from impurities atoms.

TOP Study

5- *Magnification of eyepiece = $1 + d / f_e$*

TELESCOPE

Telescope is an optical instrument, which enables the observer to see fine details of a far off object.

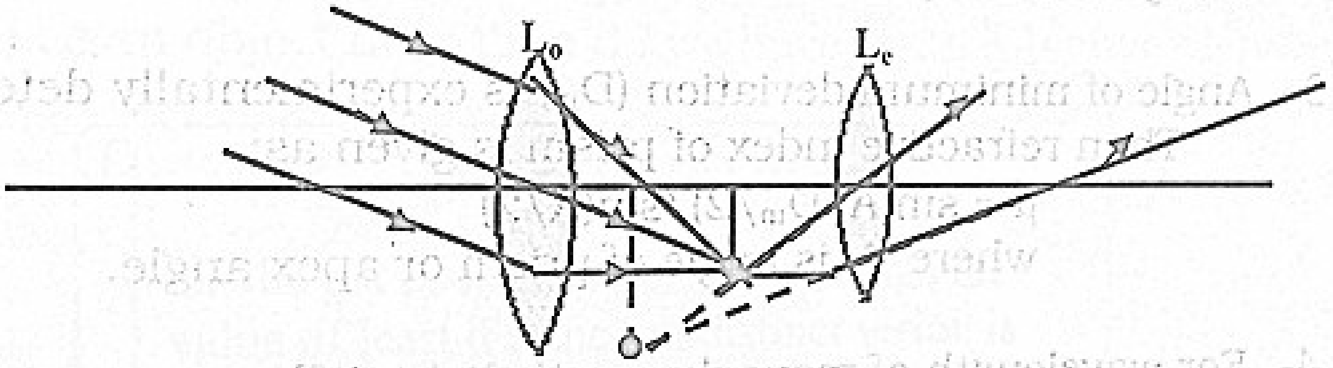
- Two major classes of telescopes are given below:
  1- Reflecting telescopes
  2- Refracting telescopes
    - Astronomical
    - Galilean
    - Terrestrial

ASTRONOMICAL TELESCOPE

- It is used to see images of heavenly bodies.
- It consists of two lenses.
  (a) Objective is double convex lens of large focal length and large size.
  (b) Eyepiece is a double convex lens of short focal length and small size.

⇒ When set for ∞, then-

$$L = f_o + f_e$$



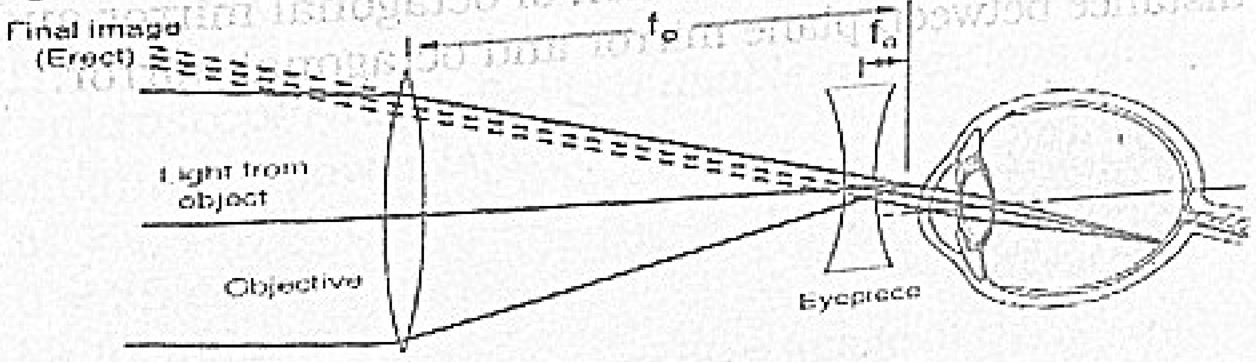
- Advantages:
  1- High magnifying power
  $M = f_o/f_e$
  2- Large field of view.
- Disadvantages:
  Final image is inverted.

Do you know?

A good telescope has an objective of long focal length and large aperture.

GALILEAN TELESCOPE

The Galilean or terrestrial telescope uses a positive objective and a negative eyepiece. It gives erect images and is shorter than the astronomical telescope with the same power. It's angular magnification is $-f_o/f_e$.



SPECTROMETER

It is an optical instrument used to study spectra.

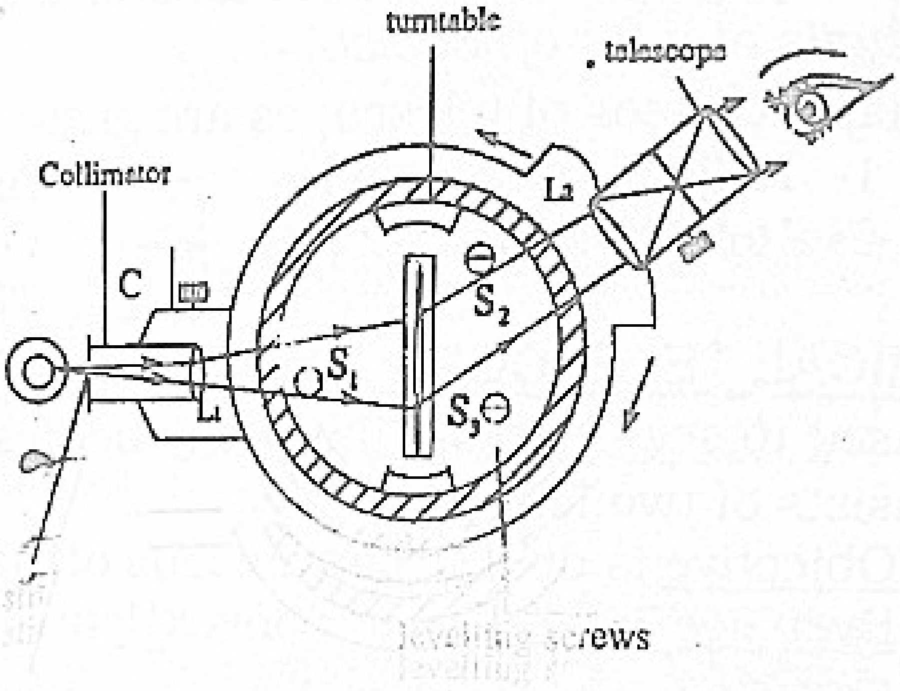
- It has following parts: -

1- Collimator: It has slit at focus of a double convex lens to get a parallel beam of light.

2- Telescope: It is an astronomical telescope.

3- Turn table: Prism or diffraction grating is placed on table called turn table.

4- Leveling screws



- Working

1- Telescope is set for infinity and fixed.

2- Source of monochromatic light is placed in front of slit and collimator is adjusted for parallel rays.

3- Angle of minimum deviation (D_m) is experimentally determined. Then refractive index of prism is given as:

$\mu = \sin[(A+D_m)/2]/\sin(A/2)$

where 'A' is angle of prism or apex angle.

4- For wavelength of monochromatic light diffraction grating is used:

$d \sin\theta = m\lambda$

$\lambda = d \sin\theta/m$

Usually m = 1 (first order diffraction).

d = grating element

= $1/N$

SPEED OF LIGHT

- First attempt to measure the speed of light was made by Galileo.
- First time speed of light measured accurately by Michelson.
- The Michelson`s formula for determination of speed of light is:

$C = 16fd$

where f is frequency of rotation of octagonal mirror and d is distance between plane mirror and octagonal mirror.

Raleigh shows that resolving power of a lens of aperture D, under a light source of wavelength λ is. $R = \frac{D}{1.22\lambda}$

Lens Aberrations

1- Spherical aberration

It is the formation of blurred image due to size of lens because outer rays undergo more refraction than the inner ones.

2- Colour (chromatic)

It is inability of lens to bring all light rays (all colours) at single focus. Multicoloured blurred image is formed.

Remedy

Provide such constraints on the lens that allows only paraxial rays to enter the lens.

Remedy

Use the combination of convex and concave lenses called as achromatic lenses.

LEAST DISTANCE OF DISTINCT IMAGE

It is minimum distance up to which a normal eye can see an object clearly.

$d = 25cm$

To see an object near than d , we have to use a convex lens.

Do you know?

As the get over the years upto old age the value of least distance of distinct vision is drastically effect

OPTICAL INSTRUMENTS

Optical instruments are those, which use light for their operations e.g.

1. Simple microscope
2. Compound microscope
3. Telescope
4- Camera
5- Michelson interferometer
6- Spectrometer
7- Periscope

SIMPLE MICROSCOPE

Simple microscope/magnifier is a double convex lens of short focal length.

⇒ Its magnifying power is:

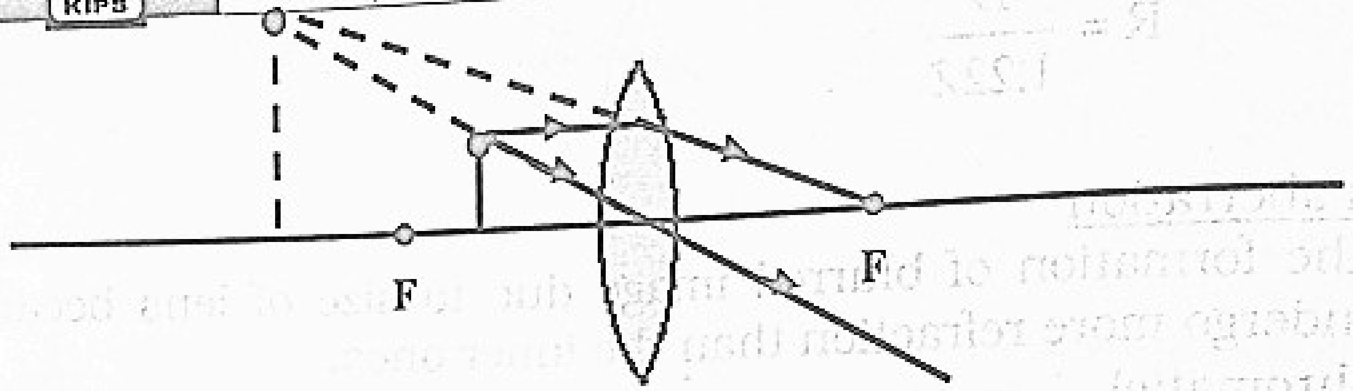
$M = 1 + d/f$

$d = 25$ cm

f = focal length.

⇒ It forms virtual, erect and magnified image at d.

$M \propto 1/f$



COMPOUND MICROSCOPE

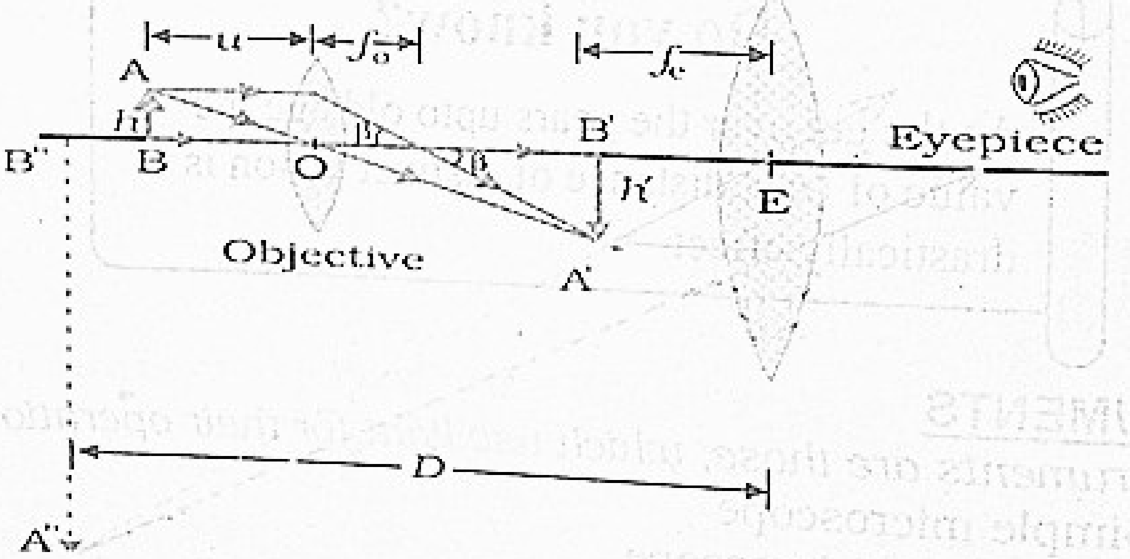
Compound microscope consists of two convex lenses.

(a) **Objective lens** of small size and short focal length.

(b)**Eyepiece lens** of large size and large focal length.

A compound microscope uses a very short focal length objective lens to form a greatly enlarged image. This image is then viewed with a short focal length eyepiece used as a simple magnifier. The image should be formed at infinity to minimize eyestrain.

The general assumption is that the length of the tube L is large compared to either f_o or f_e so that the following relationships hold.



$$M = L/f_o\,(1 + d/f_e)$$

Do you know?

A wider objective and use of blue light of short wavelength produces less diffraction and allows more details to be seen

Note:

1- $f_o < f_e$ *always* otherwise it will becomes astronomical telescope.

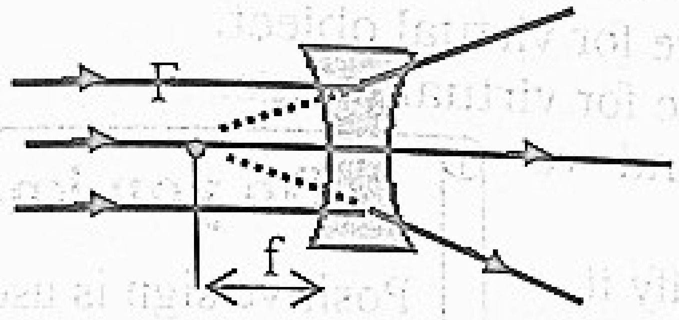
2- In case of expensive microscopes, eye-piece and objectives are combination of lenses to reduce lens defects.

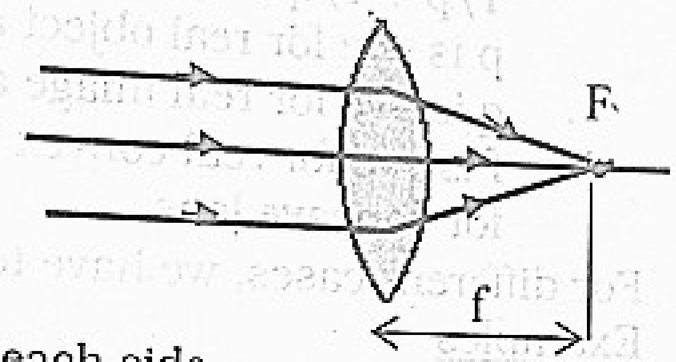
3- Objective forms real image while eyepiece forms virtual image.

4- *Magnification of objective* = L / f_o

(a) For convex lens, principle focus is a point of convergence of refracted light ray. It is a real point.

(b) For concave lens, principal focus is a point of divergence of refracted light rays. It is imaginary point.





Every lens has two foci one on each side.

- ***Optical centre*** is a point inside the body of lens through which light rays pass, undeviated.
- ***Focal length*** is a distance between principal focus and optical center. It is positive for convex lens and negative for concave lens.
  Note: It is not necessary that two focal lengths are equal.
- ***Aperture*** is the size of diameter of lens.
- ***Power of a lens*** is its ability to deviate light ray from its original path.
  $P = 1/f$
  where 'f' is focal length in meter.
  If 'f' is in cm, then-
  $P = 100/f$
- SI unit of power of lens is dioptre.
  $P = 1D$ if $f = 1m$

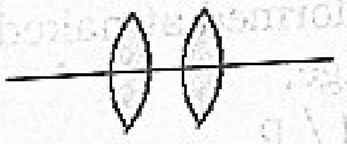
General rule for combination of 'n' lenses

General rule for combination of 'n' lenses is

$$P = P_1 + P_1 + \text{-----------} + P_n$$

Examples

For two double convex lenses;



$P = P_1 + P_2$

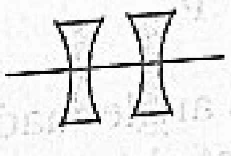
$1/f = 1/f_1 + 1/f_2$

$1/f = f_1+f_2/f_1f_2$

$f = f_1f_2/f_1+f_2$

Thus combination behaves as a convex lens.

For two concave lenses;



$P = P_1 + P_2$

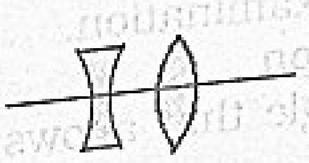
$1/f = -1/f_1 - 1/f_2$

$= -(f_1+f_2)/f_1f_2$

$1/f = -f_1f/f_1+f_2$

Thus combination behaves as a concave lens.

For one convex and other concave lens;



$P = P_1 + P_2$

$1/f = 1/f_1 - 1/f_2$

$= f_2-f_1/f_1f_1$

$f = f_1f_2/f_2-f_1$

Thus combination may behave as a convex or concave lens.

Chapter 10 Optical Instruments

Lens Formula

- General lens formula is given as:

  $1/p + 1/q = 1/f$

  p is +ve for real object and -ve for virtual object.

  q is +ve for real image and -ve for virtual image.

  f is +ve for real convex lens and -ve for concave lens.
- For different cases, we have to modify it.

  Examples

  For a virtual object;

  $1/p + 1/-q = 1/f$

  For concave lens;

  $1/p + 1/-q = 1/-f$

> **Do you know?**
>
> Positive sign is used where rays actually intersect. If not then we can use negative sign

Position and Nature of Image for Convex Lens

Position of object	*Position of image*	*Nature of image*
Beyond 2F	*Between F and 2F*	*Real, inverted, small*
At 2F	*At 2F*	*Real, inverted, equal*
Between F and 2F	*Beyond 2F*	*Real, inverted, enlarged*
At F	*At infinity*	*Real, inverted, enlarged*
Inside F	*On same side further away from lens than the object*	*Virtual, erect, enlarged*

Magnification of a Lens

- Linear magnification is given as:

  $M = q / p \quad = h_i/h_o \quad$ = size of image / size of object
- Angular magnification is given as:

  $M = \theta_i / \theta_o$ = Angle formed at aided eye / Angle formed at naked eye
- For real image;

  $M = q / p$
- For virtual image;

  $M = -q / p$

> **Do you know?**
>
> For very small angles we can equate linear and angular magnifications.

Visual Angle

- Visual angle is angle made by object at observer's eye.
- Apparent size of object varies with visual angle.

  Apparent size ∝ visual angle

Resolving Power

The resolving power of an instrument is its ability to reveal the minor details of the object under examination.

Angle of Resolution

The minimum angle that allows two point sources to appear distinct is called angle of resolution it is expressed as $\alpha_{\min}$

$$\alpha_{\min} = 1.22\frac{\lambda}{D}$$

PRACTICE EXERCISE

30 min Time Yourself

(1) When light waves performs interference then which of the following quantity remain conserved

(a) intensity
b) energy
c) momentum
(d) all of these

(2) A point where the incident parallel rays of light converge or appear to diverge after passing through a lens is called

(a) center of curvature
(b) focus
(c) optical center
(d) aperture

(3) The diameter of a lens is called

(a) focal length
(b) principal axis
(c) aperture
(d) radius of curvature

(4) In going form a denser to rarer medium a ray of light is

(a) undeviated
(b) bent away form the normal
(c) bent towards the normal
(d) polarized

(5) Unit of power of a lens is

(a) meter
(b) watt
(c) dioptre
(d) horsepower

(6) The diamond shines due to

(a) Interference
(b) diffraction
(c) scattering
(d) total internal reflection

(7) If a lens is covered with wax then

(a) Intensity become double
(b) Image will not formed
(c) Intensity will remain same
(d) Intensity will become half

(8) The minimum distance between an object and its real image in a convex lens is

(a) 2 f
(b) 2.5 f
(c) 3f
(d) 4f

(9) If an object is placed away from '2f' of a converging lens, then the image will be

(a) real and erect
(b) virtual and erect
(c) real and inverted
(d) virtual

(10) If the length of telescope is 96cm the focal lengths of its lenses is

(a) 100cm , - 4cm
(b) -80cm , -6cm
(c) 90cm , -6cm
(d) 90cm , 6cm

(11) Magnifying power of simple microscope

(a) increase with increase in focal length
(b) increase with decrease in focal length
(c) no effect with decrease or increase with focal length
(d) list distance of distinct vision

(12) Image of an object 5 mm high is only 1 cm high. Magnification produced by lens is

(a) 0.5
(b) 0.2
(c) 1
(d) 2

(13) The speed of light in the medium of refractive index is
(a) $2 \times 10^8 ms^{-1}$ (b) $3 \times 10^8 ms^{-1}$
(c) $0.5 \times 10^8 ms^{-1}$ (d) $1.5 \times 10^8 ms^{-1}$

(14) Least distance of distinct vision
(a) increases with increase in age (b) decreases with increase in age
(c) neither increases nor decreases (d) becomes infinite after 60 years

(15) If a convex lens of large aperture fails to converge the light rays incident on it to a single point, it is said to suffer from
(a) chromatic aberration (b) spherical aberration
(c) both spherical and chromatic (d) distortion

(16) Two convex lenses of equal focal length 'f ' are placed in contact, the resultant focal length of the combination is
(a) zero (b) f
(c) 2 f (d) f/2

(17) A convex lens of focal length 'f_1' and a concave lens of focal length 'f_2' are placed in contact. The focal length of the combination is
(a) $f_2 + f_1$ (b) $f_2 - f_1$
(c) $f_1 f_2/f_2 + f_1$ (d) $f_1 f_2/f_1 - f_2$

(18) Final image produced by a compound microscope with respect to the object is
(a) real and inverted (b) real and erect
(c) virtual and erect (d) virtual and inverted

(19) For normal adjustment, length of astronomical telescope is
(a) $f_o + f_e$ (b) $f_o - f_e$
(c) f_o/f_e (d) f_e/f_o

(20) A surf board moves at a speed of 5m/s on the crests of a wave. The distance between wave crests is 10m. what is the frequency of the wave motion
(a) 2 Hz (b) 5Hz
(c) 10Hz (d) 0.5Hz

(21) Dispersional effect may produce error in light signals. This type of error is minimum in
(a) single mode step index fibre (b) multimode step index fibre
(c) multimode graded index fibre (d) monomode step index fiber

(22) Light signals passes through multimode graded index fibre due to
(a) continuous refraction
(b) total internal reflection
(c) both continuous refraction and total internal reflection
(d) diffraction

(23) Which one type of fibre is more suitable for transmission of signals in which white light is used?
(a) mono mode step index fibre (b) multi mode step index fibre
(c) multi mode graded index fibre (d) single mode step index fibre

(24) Critical angle is that incident angle in denser medium for which angle of refraction is
(a) 0° (b) 45°
(c) 90° (d) 180°

(25) There is no noticeable boundary between core and cladding
(a) multi mode step index fibre
(b) multi mode graded index fibre
(c) single mode step index fibre
(d) all types of fibre

(26) The electrical signals change into light signals for transmission through optical fibre. A light pulse represent
(a) zero (0) (b) one (1)
(c) both zero (0) and one (1) (d) either zero (0) or one (1)

(27) A lens, which is thicker at the center and thinner at the edges, is called
(a) concave lens (b) convex lens
(c) plano convex lens (d) plano concave lens

(28) A spectrometer is used to find
(a) wave length of light
(b) refractive index of the prism
(c) wavelength of different colours
(d) all of the above

(29) If a convex lens of focal length 'f' is cut into two identical halves along the lens diameter, the focal length of each half is
(a) f (b) f/2
(c) 2f (d) 3f/2

(30) A convex and concave lens of focal length 'f' are in contact, the focal length of the combinations will be
(a) zero (b) f/2
(c) 2f (d) infinite

(31) If the red light is replaced by blue light illuminating the object in a microscope the resolving power of the microscope
(a) increases (b) decreases
(c) remain same (d) become half

(32) In optic fiber transmission system __________ are used to regenerate the dim light signal.
(a) Diodes (b) Repeaters
(c) Laser (d) Transformer

(33) Magnification of the astronomical telescope is
(a) fo+fe (b) fo/fe
(c) fe/fo (d) (1+fo/fe)L/fo

(34) The equation $\alpha_{min} = 1.22\,\lambda/D$ was devised by
(a) Newton (b) Einstein
(c) Raleigh (d) Planks

(35) The central image in compound microscope is
(a) virtual, erect and magnified
(b) real, inverted and smaller than object
(c) virtual, erected and magnified
(d) erect, virtual and smaller than final image

(36) Michelson calculated the speed of light using the instruments
(a) spectrometer (b) galvanometer
(c) interferometer (d) none of these

(37) Michelson devised the formula to calculate the speed of light
(a) C = 4fd (b) C = 8fd
(c) C = 16fd (d) C = 5/2fd

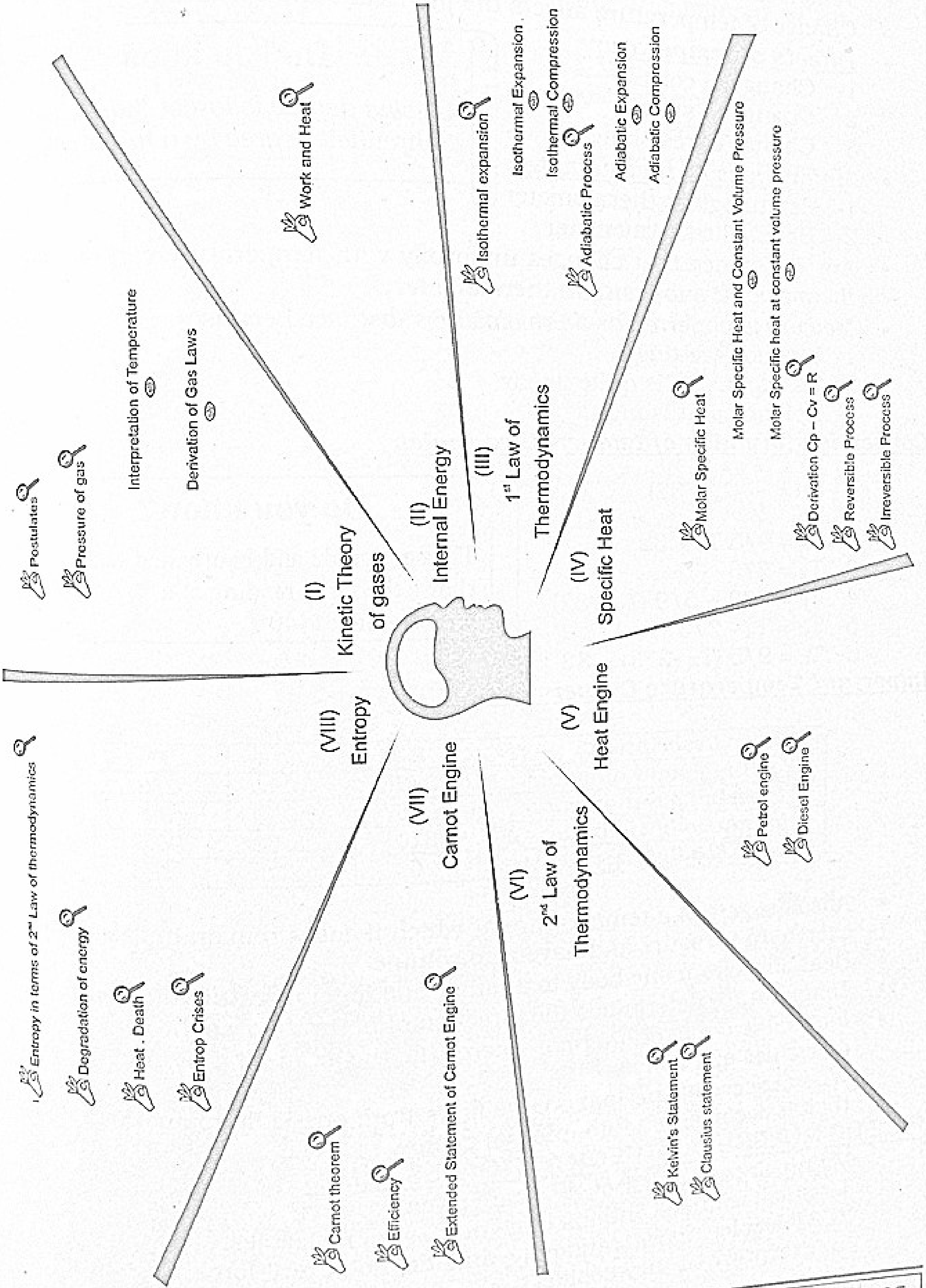
(38) The function of collimator in spectrometer is
(a) to produce parallel beams of light
(b) to filter the light rays
(c) to make them ⊥
(d) no function

(39) In optic fiber transmission the repeater are separated through a distance of ______________ km in newer system.
(a) 300km (b) 200km
(c) 100km (d) 20km

(40) Which colour has the maximum angle of deviation in prism
(a) red (b) blue
(c) orange (d) green

Chapter 11

HEAT AND THERMODYNAMICS



Chapter 11

Heat & Thermodynamics

INTRODUCTION

- *Heat* is a form of energy that is in transit.
- *Temperature* is a measure of degree of hotness or coldness of a body.
- Change of temperature affects the physical state of matter.
- ***Effects of temperature***
  1- Change of colour
  2- Change of state
  3- Change of resistance.
- ***Major types of thermometer***
  1- Mercury glass thermometer
  2- Bimetallic thermometer

> **Do you know?**
>
> *Celsius degree is larger than a Fahrenheit degree by a factor of 9/5.*

- Any substance that changes uniformly with temperature can be used as *thermometric substance* in thermometer.
- *Mercury is preferred as thermometric substance* because-
  1- It is non-wetting
  2- Its expansion is quite linear
  3- Boiling point is high.

Conversion formulas of temperature scales

1- $T_C = \frac{5}{9}(T_F - 32)$
2- $T_F = 9/5\, T_C + 32$
3- $T_K = 273 + T_C$
4- $T_K = 273 + 5/9\,(T_C - 32)$
5- $T_C = T_K - 273$
6- $T_F = 9/5\,(T_K - 273) + 32$

> **Do you know?**
>
> The centigrade and Fahrenheit scale shows the same reading at a temperature of -40°.

Important Temperature Conversions

Description	K	C°	F°
Boiling point of water	373	100	212
Freezing point of water	273	0	32
Normal body temperature	310	37	98.6
Absolute zero	0	– 273	–460

- *Absolute zero* is a temperature at which if gases remain in gaseous form, exert zero pressure and have zero volume.
- Heat flows from one body to another due to temperature difference.
- Temperature determines the direction of natural flow of heat.
- *Internal energy or thermal energy* is the sum of K.E and PE of all molecules of a body.
- When excess of thermal energy flows from one body to another, as heat, then it is converted into internal energy.

KINETIC MOLECULAR THEORY OF GASES (K.M.T)

Main points of K.M.T of gases are given as:

1- Small volume contains large number of molecules.
2- Molecules move randomly and do not exert force on one another except when they collide.

3- Molecules collide each other elastically.
4- The collisions with walls give rise to gas pressure.
5- Gravity does not affect the molecular motion.
6- Volume of gas molecules this negligible as compared to the actual volume of the gas.

PRESSURE AND TEMPERATURE OF AN IDEAL GAS

The kinetic theory of gases is the study of the microscopic behavior of molecules and the interactions which lead to macroscopic relationships like the ideal gas law.

Assumptions

Number of molecules is very large, but separation is large compared to molecular size.

Molecules move randomly with a distribution in speeds which does not change.

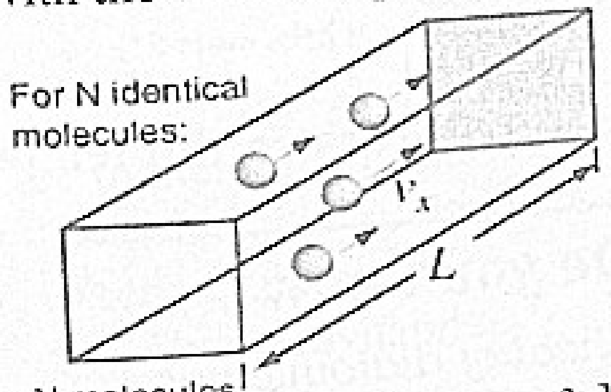
Molecules undergo elastic collisions with other molecules and the walls, but otherwise exert no forces on each other.

Molecules obey Newton's Laws of motion.

Developments will be made with collections of identical molecules, but the results can be generalized.

Newton's Laws and Collisions:

Applying Newton's law an ideal gas under the assumptions of kinetic theory allows the determination of the average force on container walls. This treatment assumes that the collisions with the walls are perfectly elastic.



For N molecules

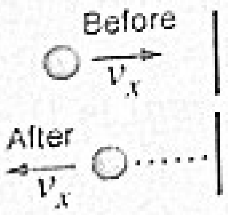
$$\bar{F} = \frac{m\left[v_{1x}^2 + v_{2x}^2 + v_{3x}^2 + \dots \; v_{Nx}^2\right]}{L}$$

but this can be related to the average:

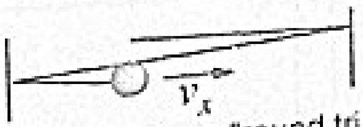
$$\overline{v_x^2} = \frac{\left[v_{1x}^2 + v_{2x}^2 + v_{3x}^2 + \dots \; v_{Nx}^2\right]}{N}$$

Force of molecular collision with wall

$$\bar{F}\Delta t = \Delta p = 2mv_x$$



Perfectly elastic collision with wall



The time for a "round trip" is $\Delta t = \frac{2L}{v_x}$

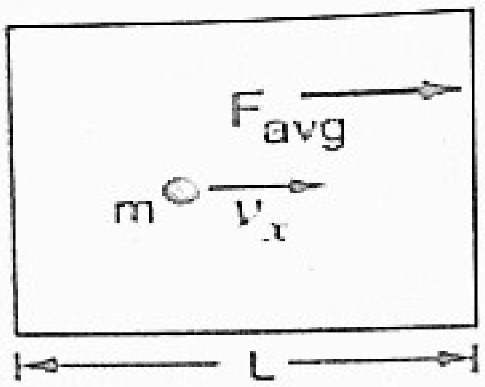
so the average force is $\bar{F} = \frac{2mv_x}{\frac{2L}{v_x}} = \frac{mv_x^2}{L}$

and for N molecules: $\bar{F} = \frac{mN\overline{v_x^2}}{L}$

In the expression for the average force from N molecules, it is important to note that it is the average of the square of the velocity which is used, and that this is distinctly different from the square of the average velocity.

Gas Pressure from Kinetic Theory:

Under the assumptions of kinetic theory, the average force on container walls has been determined to be



The average force and pressure on a given wall depends only upon the components of velocity toward that wall. But it can be expressed in terms of the average of the entire translational kinetic energy using the assumption that the molecular motion is random.

$$F_{average} = \frac{mN\overline{v_x^2}}{L}$$

and assuming random speeds in all directions

$$\overline{v^2} = \overline{v_x^2} + \overline{v_y^2} + \overline{v_z^2} = 3\overline{v_x^2}$$

Then the pressure in a container can be expressed as

$$P = \frac{F_{avg}}{A} = \frac{mN\overline{v^2}}{3LA} = \frac{mN\overline{v^2}}{3V} = \frac{N}{3V}m\overline{v^2}$$

and hence the pressure is

$$P = \frac{2}{3}N_o < \frac{1}{2}mv^2 >$$

- *Absolute temperature of a gas is a measure of its average translational K.E of all gas molecules .It is given as;*

  $T \quad = 2N_A / 3R <K.E>$
- We can relate the temperature and pressure of a gas is given as;

  $T \quad = 2N / 3P <K.E>$

SPECIFIC HEATS

- Amount of heat required to raise the temperature of a substance through 1 K is called *heat capacity*, denoted by C.

  $Q = C\,m\,\Delta T$
- *Specific heat* is the amount of heat required to raise the temperature of unit mass through unit temperature.

  $Q = C_{Sp}\ \Delta T$

Do you know?

Molar specific heat of diatomic gas is greater than that of monatomic gas.

- **Avagadro's law states:**

  "Equal volumes of gases at same temperature and pressure contain equal number of molecules."
- **Law of heat exchange states:**

  "If no heat is lost to surroundings or gained from it, then-
  Heat lost = Heat gained"

INTRODUCTION TO THERMODYNAMICS

Thermodynamics is the study of the relationship between heat and other forms of energy.

- *Thermodynamic states* describe the state of a system.
- Any collection of matter having distinct boundaries is called *a system.*
- *Boyle's law states at constant temperature.*

TOP Study

$PV=K$ OR $P_1V_1=P_2V_2$

- *Charle's law states at constant pressure*

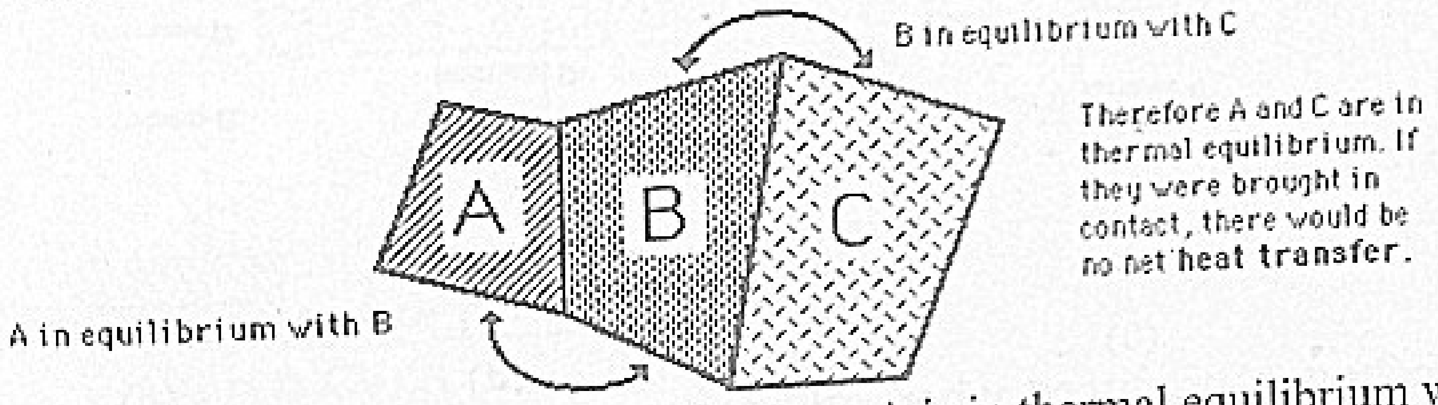
  $V / T= K$ OR $V_1 / T_1 = V_2 / T_2$
- Sum of translational K.E, rotational K.E vibrational K.E and P.E due to intermolecular forces is called *internal energy.*
- Internal energy of an ideal gas system is generally the translational K.E of its molecules.
- Increase in temperature of the object is an indication of increase in the internal energy.
- Internal energy is similar to the gravitation P.E
- *Work done on a system in which gas is enclosed is written as* $W = P\Delta V$

LAWS OF THERMODYNAMICS

Thermal Equilibrium:

It is observed that a higher temperature object which is in contact with a lower temperature object will transfer heat to the lower temperature object. The objects will approach the same temperature, and in the absence of loss to other objects, they will then maintain a constant temperature. They are then said to be in thermal equilibrium. Thermal equilibrium is the subject of the Zeroth Law of Thermodynamics.

ZEROTH LAW: The "zeroth law" states that if two systems are at the same time in thermal equilibrium with a third system, they are in thermal equilibrium with each other.



Therefore A and C are in thermal equilibrium. If they were brought in contact, there would be no net heat transfer.

If A and C are in thermal equilibrium with B, then A is in thermal equilibrium with B. Practically this means that all three are at the same temperature, and it forms the basis for comparison of temperatures. It is so named because it logically precedesthe First and Second Laws of Thermodynamic

FIRST LAW

When heat is transformed into other forms of energy total heat remains constant.

$$\Delta Q = \Delta U + W$$

where ΔQ is +ve when heat is added and vice versa.

ΔW is –ve when work is done by system and vice versa.

Inferences from 1st Law of Thermodynamics

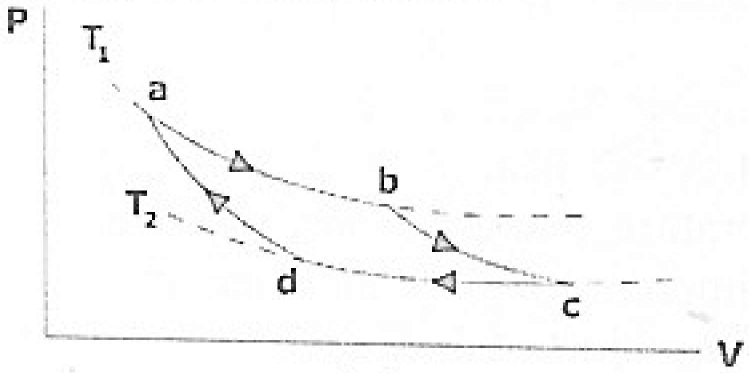
- $\Delta U = \Delta Q - \Delta W$

  Change in internal energy = Heat energy flowing in – Energy flowing out as mechanical work
- Internal energy is a state function. i.e. depends on initial and final states
- *For a cyclic system,* we have-

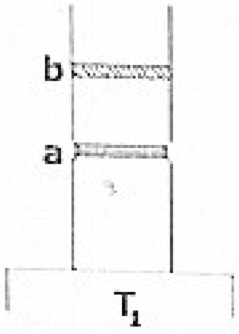
$\Delta U = 0$
$U_i = U_f$
$\Delta Q = \Delta W$

Applications of 1st law of Thermodynamics

- Isothermal process is that in which temperature remains constant.
  $\Delta Q = \Delta W \qquad \Delta U = 0$
- Isochoric process is that in which volume remains constant.
  $\Delta Q = \Delta U \qquad \Delta W = 0$
- Isobaric process is that in which pressure remains constant.
  $\Delta Q = \Delta U + P\Delta V$
- Adiabatic process is that in which no heat enters or leaves the system such that temperature remain constants



(a)



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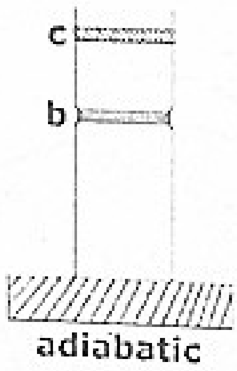
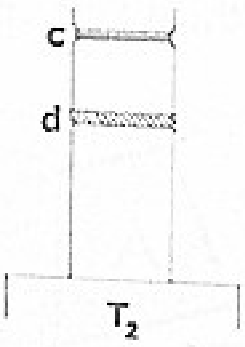


(c)



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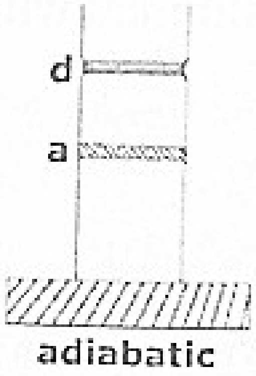
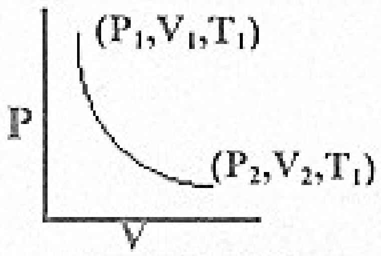


(e)

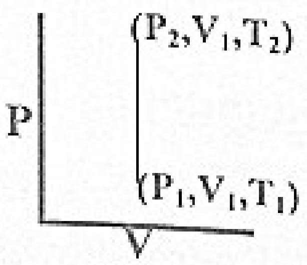
NOTE: Cooling is produced when adiabatic expansion takes place and heating is produced during adiabatic compression.

Adiabatic process is also termed as isentropic process i.e. a process in which the entropy of the system remains constant.
Rapid escape of air from automobile tyre is an example of adiabatic expansion.

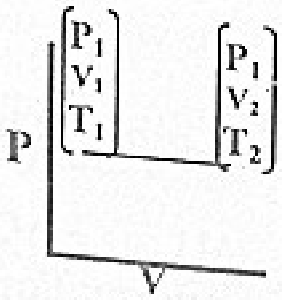
Graphical Representation



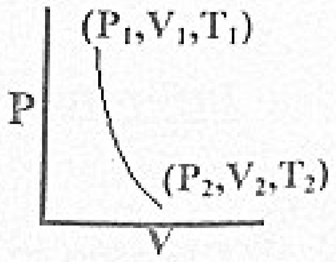
ISOTHERMAL PROCESS



ISOCHORIC PROCESS



ISOBARIC PROCESS



ADIABATIC PROCESS

Chapter 11 Heat & Thermodynamics

Do you know?

During adiabatic expansion work is done at the expense of drop in internal energy.

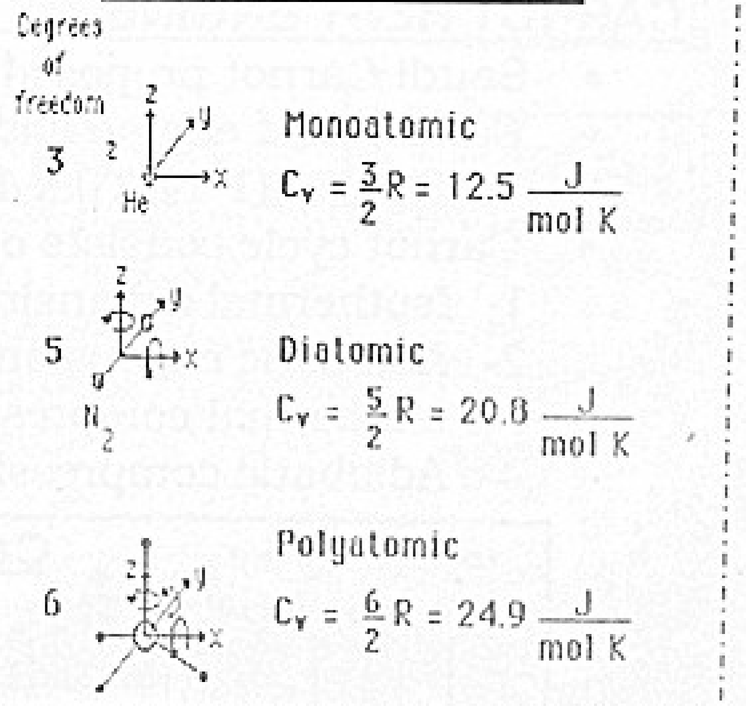
Thermodynamic Processes:

Process	Definition of process	Equation of Process	1st law applied to it ($\Delta Q = \Delta U + \Delta W$)
Isothermal	Constant temperature	PV = constant	$\Delta U = 0,\ \Delta Q = \Delta W$
isobaric	Constant pressure	V/T =constant	$\Delta W = P\Delta V$ $\Delta Q = \Delta U + P\Delta V$
Isochoric	Constant volume	P/T = constant	V = 0 $\Delta Q = \Delta W$
adiabatic	Total heat	PV^{γ} = constant	$\Delta Q = 0$ $\Delta U = -\Delta W$

C_P is greater in value than C_V

- $\Delta Q_V = n\, C_V\, \Delta T$ (Heat supplied at constant volume).
- $\Delta Q_P = n\, C_P\, \Delta T$ (Heat supplied at constant pressure).
- $C_P - C_V = R.$
- $C_P/C_V = \gamma$

For Your Information



Degrees of freedom		
3	Monoatomic	$C_v = \frac{3}{2}R = 12.5\ \frac{J}{mol\ K}$
5	Diatomic	$C_v = \frac{5}{2}R = 20.8\ \frac{J}{mol\ K}$
6	Polyatomic	$C_v = \frac{6}{2}R = 24.9\ \frac{J}{mol\ K}$

REVERSIBLE AND IRREVERSIBLE PROCESSES

- *Sequence of processes carried out in such a manner that the values of thermodynamic variables are retrieved at the end of processes then this process is called reversible process. Otherwise called irreversible.*
- *Liquefaction, evaporation and compression performed slowly* are reversible processes.
- *All changes that occur suddenly or involve friction or dissipation of energy through condition, convection or radiation* are irreversible processes.

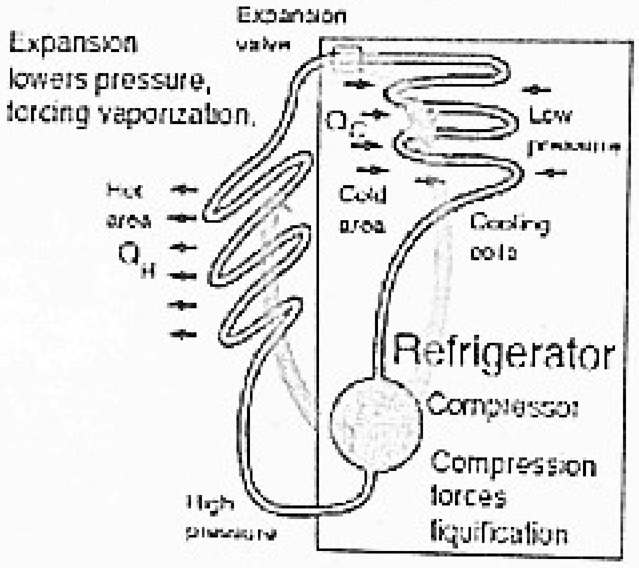
Second Law of Thermodynamics

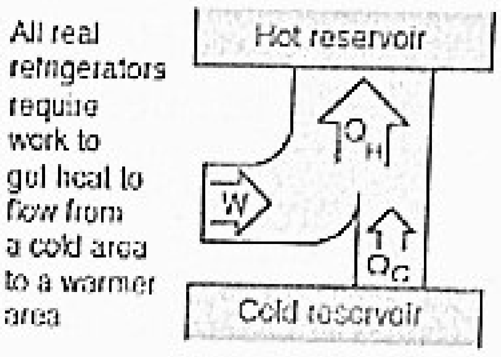
SECOND LAW

1- **Kelvin Statement:** *"It is impossible to construct a heat engine which converts all heat energy absorbed from source without having a sink."*

2- **Clausius's Statement:** *"It is impossible to transfer heat from cold to hot region without expenditure of external energy."*

Refrigerator:A refrigerator is a heat engine in which work is done on a refrigerant substance in order to collect energy from a cold region and exhaust it in a higher temperature region, therby further cooling the cold region.




All real refrigerators require work to get heat to flow from a cold area to a warmer area
Hot reservoir
Q_H
W
Q_C
Cold reservoir

HEAT ENGINE

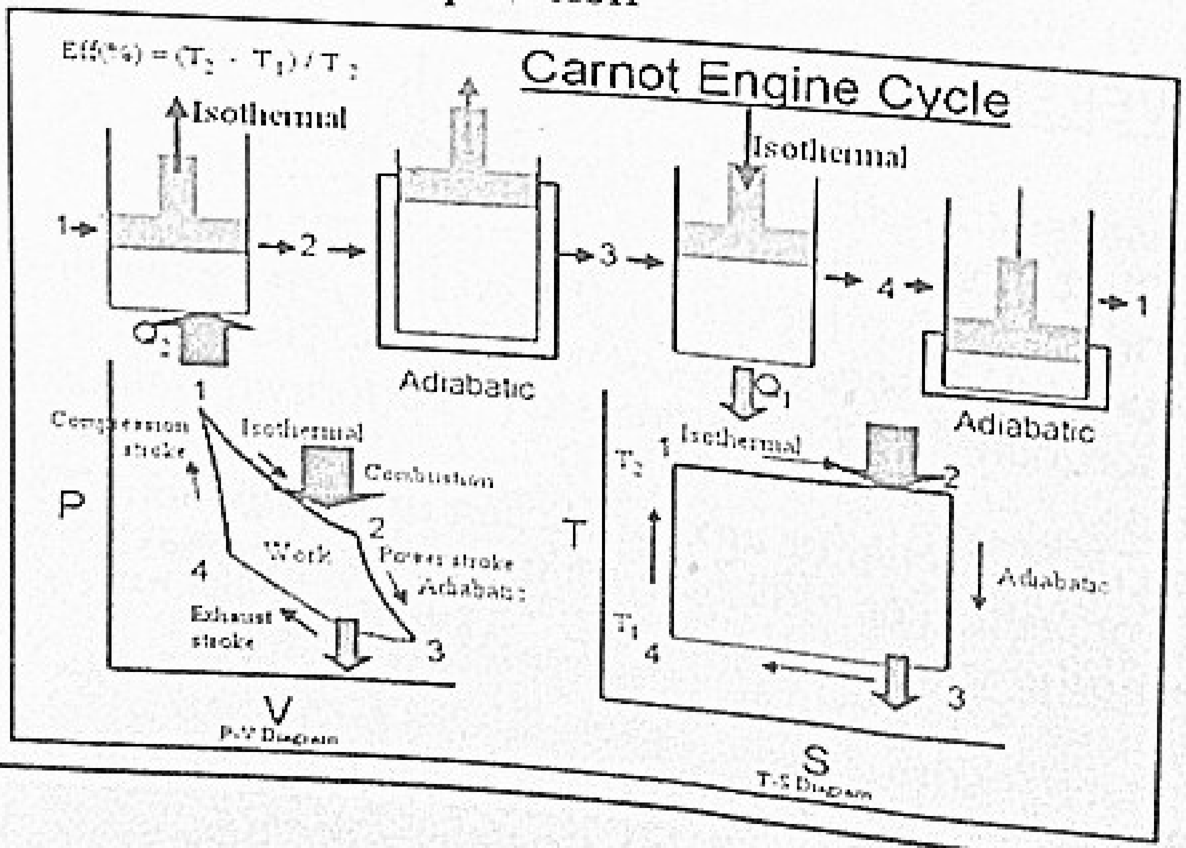
Heat engine is a thermo device, which converts heat energy into mechanical energy.

- There exists no perfect heat engine.
- Heat engine always operates in a cycle.
- *Cycle* means set of changes, which bring a system to its initial state.

CARNOT HEAT ENGINE

- Saudi Carnot proposed it in 1840. (ideal Engine).
- Carnot heat engine has maximum efficiency, but not 100%.

  $\eta_c = (1 - T_2/T_1) \times 100$
- Carnot cycle consists of following processes;
  1- Isothermal expansion.
  2- Adiabatic expansion.
  3- Isothermal compression.
  4- Adiabatic compression



Do you know?

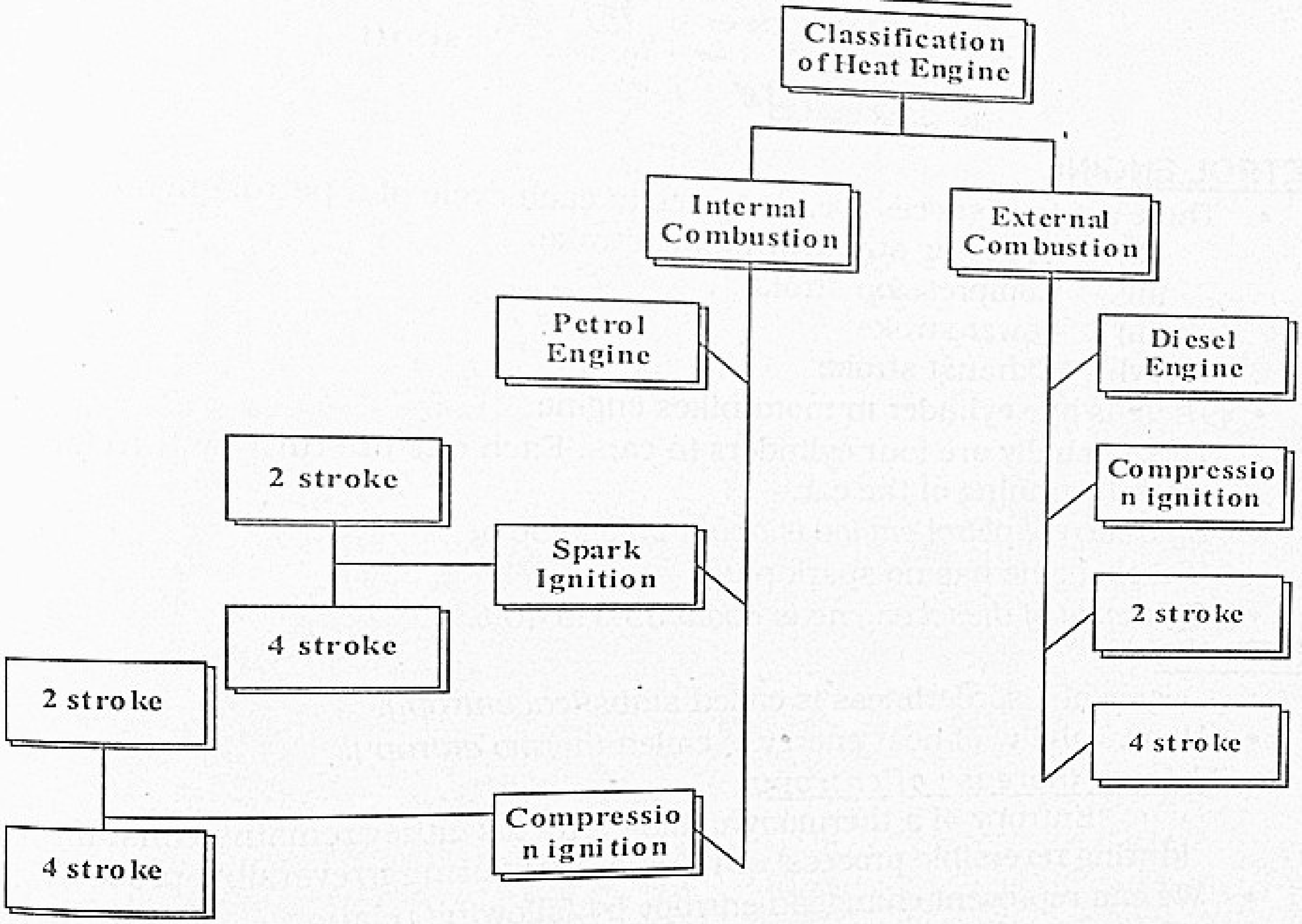
The area under the PV diagram gives us the work done by the engine.

TOP Study

- Following things should be kept in mind about efficiency of Carnot engine: -
  1- *It depends upon ΔT*
  2- *It is independent of working substance*
  3- *It is 100% only when $T_2 = 0\,K$ OR $T_1\ \alpha\ K$*

Carnot engine cannot be constructed practically.

CLASSIFICATION OF HEAT ENGINE



HEAT ENGINE

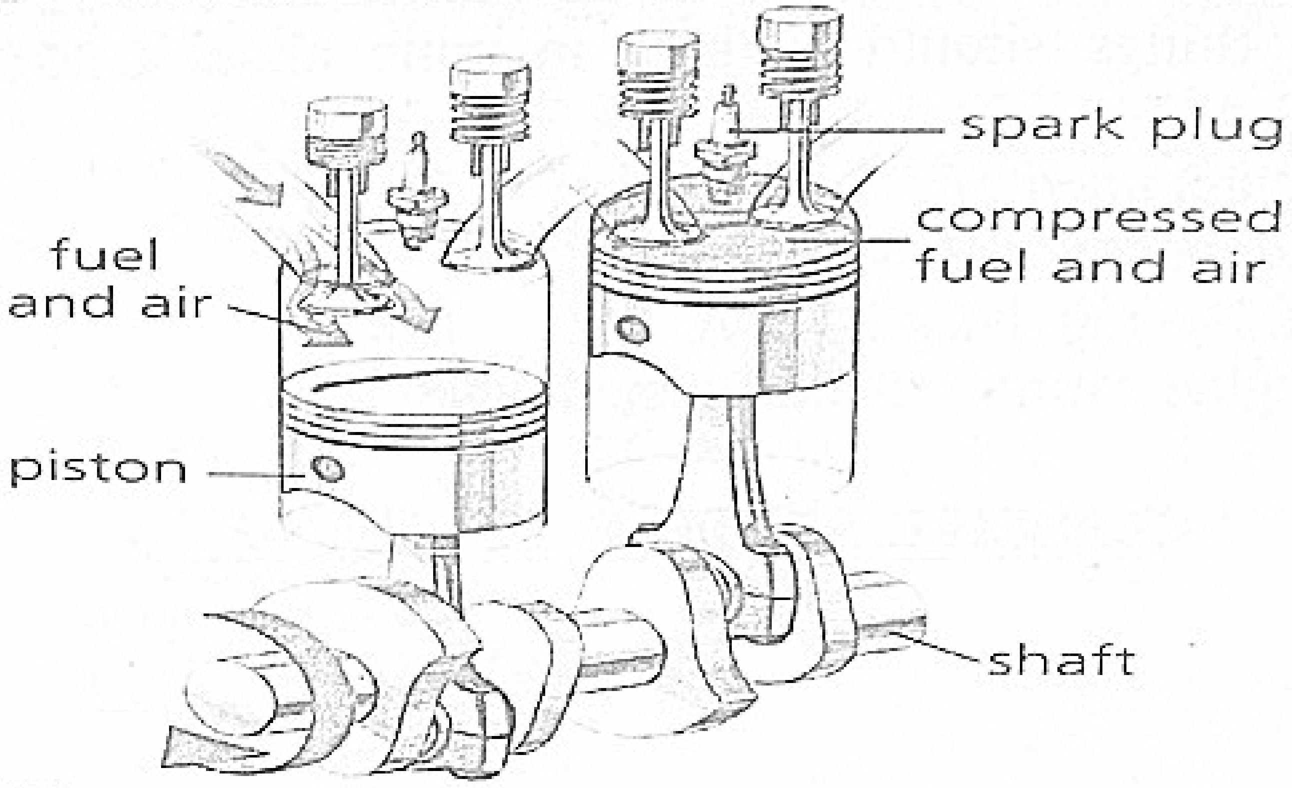
There are four major parts of every engine.

1- Cylinder
2- Piston
3- Crank shaft
4- Connecting rod

The piston oscillates within the constraints of the cylinder and this reciprocating movement is converted to rotary motion by the relative movement of crankshaft and connecting rod.

See the figure for explanation

TOP Study



PETROL ENGINE

- There are four successive processes in each cycle of a petrol engine.
  - (i) Charging stroke or intake stroke
  - (ii) Compression stroke
  - (iii) Power stroke
  - (iv) Exhaust stroke
- There is one cylinder in motorbikes engine
- There usually are four cylinders in cars. Each one fire turn by turn for smooth running of the car.
- *Efficiency of petrol engine is about 25% to 30%.*
- Diesel engine has no spark plug.
- *Efficiency of diesel engine is about 35% to 40%.*

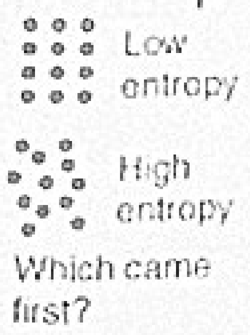
ENTROPY

- Degree of disorderliness is called *statistical entropy.*
- Unavailability of heat energy is called *thermo entropy.*
- ***Law of increase of entropy***

  "Entropy of a thermodynamic system is either remains constant (during reversible process) or it increases (during irreversible process)".
- We can represent change in entropy by following relation;

  $$\Delta S = \Delta Q/T$$

  Where ΔS is +ve if heat enters and vice versa.
- Its unit is J / K.
- Entropy may remain constant for a reversible process.
- Entropy increases for all irreversible processes.

Entropy:	a state variable whose change is defined for a reversible process at T where Q is the heat absorbed.	$\Delta S = \frac{Q}{T}$  Low entropy High entropy Which came first?
Entropy:	a measure of the amount of energy which is unavailable to do work.	
Entropy:	a measure of the disorder of a system.	
Entropy:	a measure of the multiplicity of a system. (Point to ponder)	

ENVIRONMENTAL CRISIS AS ENTROPY CRISIS

- Entropy is a time arrow.
- Increase of entropy leads to heat death of universe because thermal pollution is an inevitable consequence of 2nd law of thermodynamics.
- Environmental crisis is an entropy or disorder crisis resulting from our futile efforts to ignore the 2nd law of thermodynamics

PRACTICE EXERCISE

30 min Time Yourself

(1) At absolute temperature, the K.E of the molecules
(a) Become minimum (b) become maximum
(c) Become zero (d) None of these

(2) Temperature is a property, which determines
(a)How much heat a body contains
(b) Whether a body will feel hot or cold to touch
(c) In which direction heat will flow between two systems
(d) How much total absolute energy a body has

(3) We prefer mercury as a thermometric substance because
(a) Over a wide range of temperature its expansion is uniform
(b) It does not stick to thermometer glass
(c) It is opaque to light
(d) All of above

(4) The scales of temperature are based on two fixed points, which are
(a) The temperatures of water at 0°C and 100°C
(b) The temperature of melting ice and boiling water at atmospheric pressure
(c) The temperatures of ice cold and boiling water
(d) The temperatures of frozen and boiling mercury

(5) What does V represent in the equation $PV/2 = RT$
(a) Volume of n mole of gas (b) Mass of 4g of gas
(c) Mass of 2gm of gas (d) Volume of 3 mole of gas

(6) In a clinical thermometer, the mercury in the capillary tube does not contract once removed from the patient because
(a) Mercury takes a long time to contract
(b) The amount of mercury use is very small
(c) The capillary tube has a small constriction near the bulb
(d) The capillary tube is very narrow

(7) Normal human body temperature 98.6°F corresponds to
(a) 37°C (b) 42°C
(c) 55°C (d) 410°C

(8) The Fahrenheit and centigrade scales agree to
(a) -40 (b) 15.5
(c) 542 (d) –273

(9) The kinetic energy of the molecular motion appears as
(a) P.E (b) heat
(c) temperature (d) none if these

(10) Heating of water under atmospheric pressure is an
(a) adiabatic process (b) isothermal process
(c) isochoric process (d) isobaric process

(11) According to Pascal's law the pressure of gas in a vessel is
(a) Different in different direction
(b) Same in all direction
(c) Same only along opposite directions
(d) Same only along normal directions

(12) We can produce heat by
(a) Frictional process
(b) Chemical processes
(c) Electrical processes
(d) All of the above

(13) Which one is true for internal energy?
(a) It is sum of all forms of molecular energies of a system
(b) It is a state function of a system
(c) It is proportional to transnational K.E of the molecules
(d) All are correct

(14) At what temperature the adiabatic process is equivalent to the isothermal process
(a) 0°C
(b) Zero kelvin
(c) Critical temperature
(d) None of these

(15) Which one is not an example of adiabatic process?
(a) rapid escape of air from a burst tyre
(b) rapid expansion of air
(c) conversion of water into ice in refrigerator
(d) cloud formation in the atmosphere

(16) The pressure exerted by a column of mercury 76cm high and at 0°C is called
(a) 1 atmosphere
(b) 1 Newton per square meter
(c) 1 Pascal
(d) data is insufficient

(17) Standard condition (STP) refer to a gas at
(a) 76cm, 0°C
(b) 760mm, 273K
(c) 1 atm, 273 K
(d) all of the above

(18) If the volume of a gas is held constant and we increase its temperature then
(a) its pressure is constant
(b) its pressure rises
(c) its pressure falls
(d) any of above

(19) "If the pressure of a given gas is held constant its density is inversely proportional to its absolute temperature". It is the statement of
(a) Boyle's law
(b) Charle's law
(c)Ideal gas law
(d) Avagadro's law

(20) Boyle's law holds for ideal gases in
(a) isochoric processes
(b) isobaric processes
(c) isothermal processes
(d) adiabatic processes

(21) Gas molecules of different masses in the same container have the same average transnational kinetic energy, which is directly proportional to their
(a) volume
(b) pressure
(c) absolute temperature
(d) time

(22) Which one is correct relation?
(a) $C_p+C_v=\gamma$
(b) $C_p=1+R/C_v$
(c) $\gamma=C_p/C_v$
(d) $C_p=1-R/C_v$

(35) In which process all the heat supplied is converted into work done.
(a) isothermal
(b) isochoric
(c) isobaric
(d) none of these

(36) For the successful operation of Heat engine which condition should be met.
(a) cyclic process
(b) operated at certain temperature difference
(c) both (a) and (b)
(d) none of these

(37) The performance of a refrigerator is described by
(a) efficiency
(b) coefficient of performance
(c) both (a) and (b)
(d) not described

(38) The purpose of flywheel in the engines is
(a) to smooth out the energy variation
(b) to add more weight to engine to work it stable
(c) to start engine
(d) both (a) and (b)

(39) 1st law of thermodynamics is consequence of conservation of
(a) work
(b) energy
(c) heat
(d) all of these

(40) The door of an opening refrigerator is opened. Now the temperature of the room will
(a) remain same
(b) decreases in summer and increases in winter
(c) decreases
(d) increases

ANSWER KEY

DIAGNOSTIC TEST & PART-I

KIPS DIAGNOSTIC TEST

1	A	11	B	21	A	31	C	41	C	51	A
2	A	12	C	22	B	32	D	42	D	52	D
3	D	13	B	23	D	33	B	43	A	53	B
4	D	14	C	24	A	34	C	44	D	54	C
5	B	15	B	25	B	35	C	45	B	55	B
6	C	16	D	26	C	36	B	46	C	56	D
7	C	17	D	27	A	37	A	47	C	57	C
8	C	18	C	28	C	38	C	48	B	58	B
9	D	19	B	29	D	39	A	49	D	59	C
10	A	20	A	30	A	40	C	50	C	60	D

CHAPTER-1

1	D	11	D	21	A	31	B
2	A	12	A	22	B	32	B
3	B	13	A	23	B	33	B
4	D	14	B	24	D	34	C
5	A	15	B	25	A	35	A
6	A	16	B	26	A	36	C
7	A	17	D	27	A	37	D
8	D	18	C	28	B	38	B
9	D	19	B	29	D	39	C
10	C	20	C	30	D	40	C

CHAPTER-2

1	B	11	B	21	D	31	A
2	C	12	C	22	A	32	D
3	D	13	A	23	B	33	B
4	B	14	B	24	B	34	D
5	B	15	A	25	D	35	A
6	D	16	B	26	D	36	C
7	C	17	B	27	C	37	B
8	D	18	C	28	C	38	D
9	C	19	C	29	C	39	A
10	D	20	C	30	C	40	D

ANSWER KEY

CHAPTER-3

1	B	11	D	21	C	31	A
2	D	12	B	22	B	32	B
3	C	13	D	23	A	33	A
4	C	14	D	24	B	34	B
5	D	15	A	25	A	35	B
6	A	16	A	26	B	36	A
7	A	17	C	27	C	37	A
8	A	18	B	28	A	38	A
9	C	19	C	29	B	39	D
10	D	20	C	30	A	40	B

CHAPTER-4

1	D	11	B	21	D	31	B
2	B	12	C	22	A	32	B
3	A	13	C	23	A	33	D
4	D	14	B	24	A	34	A
5	C	15	D	25	B	35	A
6	D	16	C	26	D	36	C
7	C	17	B	27	D	37	D
8	B	18	B	28	B	38	B
9	B	19	D	29	B	39	C
10	C	20	C	30	A	40	C

CHAPTER-5

1	A	11	B	21	D	31	C
2	B	12	C	22	D	32	C
3	C	13	C	23	B	33	C
4	D	14	D	24	C	34	A
5	A	15	C	25	B	35	B
6	B	16	C	26	C	36	B
7	B	17	C	27	C	37	D
8	D	18	A	28	D	38	B
9	B	19	B	29	A	39	D
10	C	20	D	30	B	40	D

ANSWER KEY

CHAPTER-6

1	B	11	A	21	C	31	A
2	A	12	A	22	A	32	C
3	C	13	A	23	D	33	B
4	A	14	B	24	D	34	B
5	B	15	B	25	B	35	A
6	D	16	C	26	C	36	B
7	B	17	C	27	D	37	A
8	D	18	D	28	A	38	A
9	C	19	B	29	C	39	A
10	D	20	B	30	D	40	A

CHAPTER-7

1	C	11	C	21	B	31	D
2	B	12	D	22	D	32	A
3	C	13	C	23	D	33	A
4	A	14	B	24	C	34	D
5	C	15	C	25	D	35	C
6	D	16	D	26	A	36	A
7	C	17	D	27	D	37	B
8	C	18	B	28	D	38	C
9	D	19	C	29	C	39	A
10	B	20	B	30	C	40	C

CHAPTER-8

1	A	11	B	21	B	31	C
2	D	12	D	22	B	32	D
3	B	13	C	23	B	33	A
4	C	14	C	24	C	34	B
5	A	15	C	25	B	35	B
6	B	16	B	26	C	36	C
7	A	17	C	27	A	37	B
8	B	18	B	28	C	38	D
9	A	19	B	29	D	39	B
10	B	20	C	30	B	40	A

ANSWER KEY

CHAPTER-9

1	B	11	C	21	D	31	D
2	C	12	D	22	D	32	C
3	C	13	C	23	C	33	A
4	D	14	C	24	B	34	B
5	D	15	C	25	C	35	A
6	D	16	C	26	C	36	C
7	C	17	B	27	B	37	D
8	C	18	B	28	D	38	B
9	D	19	B	29	C	39	A
10	B	20	C	30	A	40	C

CHAPTER-10

1	B	11	B	21	C	31	A
2	B	12	D	22	A	32	B
3	C	13	A	23	C	33	B
4	B	14	A	24	C	34	C
5	C	15	B	25	B	35	D
6	D	16	D	26	B	36	A
7	D	17	D	27	B	37	C
8	D	18	D	28	D	38	A
9	C	19	A	29	C	39	C
10	D	20	D	30	D	40	B

CHAPTER-11

1	C	11	B	21	C	31	C
2	C	12	D	22	C	32	B
3	D	13	D	23	D	33	B
4	B	14	B	24	D	34	C
5	D	15	C	25	B	35	A
6	C	16	A	26	C	36	C
7	A	17	D	27	D	37	B
8	A	18	B	28	B	38	A
9	C	19	B	29	C	39	B
10	D	20	C	30	C	40	D

KIPS ENTRY TEST SERIES

Part - II

KIPS PUBLICATION

Chapter 12

ELECTROSTATICS

(I) Coulomb's Law

- Field of force
- Electric lines of force
- Properties of electric lines of force
- Application of Electrostatic
- Xerography
- Inkjeet printers
- Millikan's Method
- Electric lines of force in parallel plates

(II) Electric Flux

- Flux through closed surface
- Gauss's Law
- Application of Gauss's Law
- 'E' inside will change sphere
- 'E' due to infinite sheet of change sphere
- E between oppositilety charged parallel plates

(III) Electric Potential

- E at point due to point charge
- Electron volt
- E as potential gradient

(IV) Capacitor

- Capacitance
- Electric Polarization of Dielectrics
- Charging the Capacitor
- Discharging the Capacitor

- The physics that deals with charges at rest is called *electrostatics.*
- *An electric force* is the force, which holds the positive and negative charges that **make up atoms, molecules** and **bodies.**

CHARGE & ITS RELATIONSHIP WITH FRICTION

- *Bodies get charge due to friction.*
- During rubbing process, free or atomic electrons gain more energy than work function and get detached thus producing positive charge.
- **Similar charges repel each other while opposite charges attracts each other.**
- *Excess of electrons* ***create negative charge*** *while their* ***deficiency produces positive*** *charge.*
- *SI unit of charge is coulomb.* It is defined as:

  "If force between two equal and opposite charges placed in a vacuum 1m apart is 9×10^9N then each of them bear 1C charge."

  OR

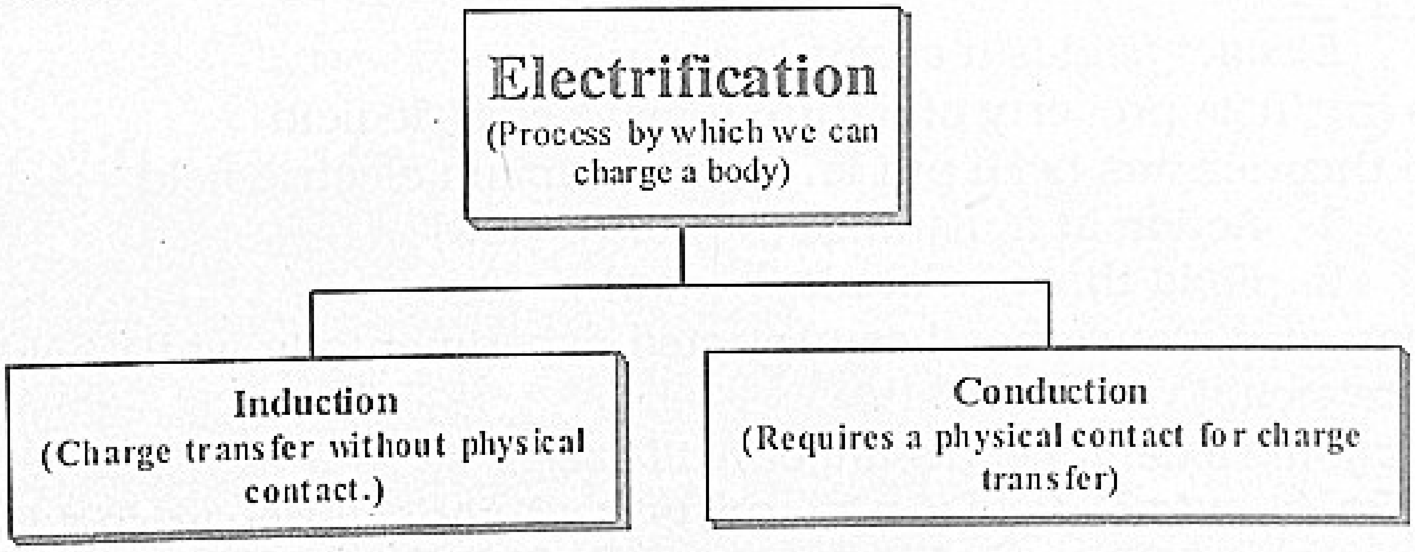
  "If 1A current flows in 1 s then charge will be IC."

  OR

  " Charge of 6.25×10^{18} electrons is 1coulomb."
- Charge is a **conserved quantity** as well as **quantized.**
- 1- Charge per unit area ($\Delta Q/\Delta A$) is called ***surface change density.***

  2- Charge per unit volume ($\Delta Q/\Delta V$) is called ***volume charge density.***

  3- Charge per unit length ($\Delta Q/\Delta L$) of straight conductor is called ***linear charge density.***
- Charges always shift from higher charge density body to lower charge density body.
- When charged particle is subjected to electric field, then its acceleration is qE/m.
- When charge is given to hollow sphere, it resides on outer surface only but not on inner surface.


Electrification
(Process by which we can charge a body)
Induction
(Charge transfer without physical contact.)
Conduction
(Requires a physical contact for charge transfer)

Electrical Forces

- Electrical forces are attractive and repulsive in nature depending upon likeness or unlikeness
- Interaction of field explains force.
- Origin of electric force is unknown.
- Coulomb used an apparatus known as ***torsion balance*** to study mathematical measurement of electrical force operating between two point charges.

Coulomb's Law

Coulomb found that electrical force between two point charges is-

1. *Directly proportional to product of their charges*
2. *Inversely proportional to square of distance between them*
3. *Act along line joining them.*

Mathematically,

$$F_e = K\,q_1\,q_2/r^2$$

Where $K = 9 \times 10^9$ N-m²/C²

In vacuum,

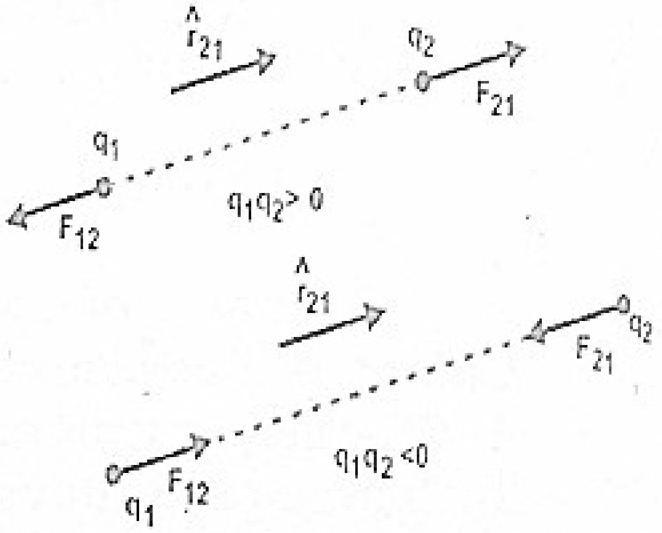
$$K = 1/4\pi\epsilon_0$$

Where ϵ_0 is permittivity of free space.

$$\epsilon_o = 8.85 \times 10^{-12}\ C^2/N\text{-}m^2$$

Do you know?

Two bodies having charge, very small in size as compared with the distance between them acts as *point charges.*



- $\vec{F}_{12}=-\vec{F}_{21}$ Shows that electrical forces form an action-reaction pair.
- Coulomb's law obeys **inverse square law.**
- *When charges are placed in medium other*
- *than air,* then force reduces by a fa **permitivity.**

$$F' = (1/\epsilon_r)\,F$$

$$F' = F/\epsilon_r$$

- In terms of electrical force, ϵ_r can be given as; $\epsilon_r = F/F'$

It means that *relative permitivity is ratio between electrical force between two point charges, when placed in air or vacuum to the electric force between them when placed in medium other than vacuum.*

- ϵ_r , the relative permitivity is unit less quantity.

ELECTRIC FIELD

Electric field is a vector quantity.

- It is intrinsic property of nature to have electric field
- Two theories has been put forward to explain electric field -
  1. Action at a distance (Newton's view)
  2. Field theory (Faraday's view)
- Action-at-distance has been rejected experimentally while field theory is a convincing view.
- *For infinite extent, field is uniform all over.*

For ***finite extent****, field is* ***non-uniform at ends.*** *(Fringing Field)*

ELECTRIC INTENSITY

- Electric intensity is given as;

$$E = F/q_o$$

Where q_o is a test charge. It is defined as the force per unit change.

- In vector form $\vec{E} = K\,q/r^2\,\hat{r}$
- *SI unit of E is N/C and V/m*

TOP Study

ELECTRIC LINES OF FORCE

Definition: *The path followed by a tiny positive charge in an electric field is called electric intensity.*

Electric lines of force are imaginary lines ***starting*** *from positive charge and* ***ending*** *on negative charge.*

Some of important properties are given below;

1- Originate from positive charge.
2- End on negative charge.
3- Do not intersect
4- Contract longitudinally.
5- Repel transversely.
6- No electric line is present inside the conductor.
7-Tangent drawn to electric lines gives the direction of electric intensity
8- Electric field is stronger where the electric lines are **closely packed**

XEROGRAPY (PHOTOCOPIER)

- "Xerox" means **"dry"**, "graphy" means, **"writing".**
- The lamp transfers the image of document as bright and dark spots on **drum** (core of the Machine).
- Drum is an aluminum cylinder coated with selenium. Selenium is a LDR (Light dependent resistor). It retains positive charge in dark.
- Positive chare document image is created on the drum.
- Toner is given negative charge and is sprayed over the drum.
- The image is then transferred on paper and is settled by the heated pressure rolls on the paper.

INKJECT PRINTERS

- It works on the thin stream of ink ejected from a nozzle at high speed.
- It passes through two electrical components. **Charging electrode** and **deflection plates.**
- Charging electrode gives a net charge to the stream. Controlled by instructions from computers.
- The uncharged drops pass without deflection through deflection plates and strike the paper while charged drops are directed to gutter.

ELECTRIC FLUX

Electric flux is the number of electric lines of force passing perpendicular through certain area.

- Mathematically electric flux is defined as;

$$\phi_e = \vec{E} \, . \, \vec{A} \; = EA\cos\theta$$

- It is a scalar quantity.
- $\phi_{max} = EA$ when $\theta = 0°$ (surface is $\perp$ to E)
  $\phi_{min} = 0$ when $\theta = 90°$ (surface is $\parallel$ to E)
- *If no. of flux lines leaving a closed surface is greater than no. of flux lines entering, then surface contains source or positive charge.*
- *If no. of flux lines leaving a closed surface is less than no. of flux lines entering it, then surface contains sink or negative charge.*

- *If no. of flux lines entering is equal to no. of flux line leaving, then surface contain neither sink nor source.*

Do you know?

Electric flux depends upon charge and medium not on shape of the closed sphere.

FLUX THROUGH CLOSED SURFACE

- Flux through closed surface is;

$$\phi_e = Q/\epsilon_o$$

It shows that flux through closed surface is independent of **location** of charges enclosed by it and **shape** of closed surface.

GAUSS'S LAW

"The flux through a closed surface is $(1/\epsilon_o)$ times the total charge enclosed in it".

$$\phi_{total} = (1/\epsilon_o)Q$$

Point to Ponder

Any apparatus placed within a metal enclosure is shielded from electric fields. Why?

Gauss's Law is applied to calculate electric intensity. For this purpose an imaginary closed surfaced called Gaussian surface is considered which passes through the points at which the electric intensity is to be evaluated.

Applications

1- Electric intensity inside a Hollow charged sphere.
Electric intensity inside a hollow charged sphere is zero.
$\mathbf{E} = 0$

2- Electric intensity due to **sheet of charge** is given as;

$$\mathbf{E} = \sigma / 2\epsilon_o \hat{r}$$

3- Electric intensity between **two oppositely charged** plates is given as.

$$\mathbf{E} = \sigma / \epsilon_o \hat{r}$$

Electrical Potential OR Potential Difference

Electric potential difference between two points is defined as:
"Work done per unit charge in moving it against electric field."
Keeping the charge in electrostatic equilibrium.

$$\Delta V = W_{A \to B}/q_o$$

- It can be given in terms of potential energy as-

$$\Delta V = \Delta U/q_o$$

- SI unit of potential difference is volt.

"If 1J of work is done on one coulomb charge between two points keeping equilibrium, the potential difference is 1V"

$$1V = 1J/1C$$

For your information

We can relate electric potential difference and electric field intensity by following relation: -

$$E = -\Delta V/\Delta r$$

Where negative shows that E is along decreasing potential
N/C is equal to V/m.
It means that-

1- We can call 'E' potential gradient because it represents the maximum rate of change of potential difference w.r.t displacement.

- *Absolute electric potential at a distance 'r' from source* is given as;

$$V_{(r)} = q / 4\pi\epsilon_o r$$

- *Absolute potential at a point due to collection of point charges* is given as;

$$V = 1/4\pi\epsilon_o \sum_{i=1}^{n} q_i/r_i$$

- **ECG** records the voltage between points on human skin generated by electrical process in the **heart.**

EQUIPOTENTIAL SURFACES

Definition: The surface on which electric potential is same at each point is called equipotential surfaces.

Example: Charged hollow sphere containing point charge at its center

- ***Characteristics of equipotential surfaces***

1-They does not intersect.
2-Potential difference between two **point charges on equipotential surface** is zero.
3-No work is done to move a point charge on an equipotential surface.
4-Work is done when point charge is moved from one equipotential surface to another.

ELECTRON VOLT

Definition: "The amount of energy acquired or lost by an electron as it transverses a potential difference of one volt"

- $1eV = 1.6\times10^{-19}J$
- $1J = 6.25\times10^{18}$ eV
- It is the unit of energy specially used for atomic particles.

COMPARISON OF GRAVITATIONAL AND ELECTROSTATIC FORCES

Particulars	Gravitational force	Electrostatic force
Formula	$F_g = Gm_1m_2/r^2$	$F_e = 1/4\pi\epsilon_o\, q_1q_2/r^2$
Range	infinite	infinite
Symbol of constant	G	$K = 1/4\pi\epsilon_o$
Value of constant	Very small	Fairly large
Nature	Always attractive	Attractive or repulsive
Dependence	Medium independent	Medium dependent
Relative strength	Weak: can be felt with massive oject	Strong at close range

MILLIKAN'S METHOD FOR ELECTRONS CHARGE

- Atomizer sprays oil drops
- The droplet between the two plates could be suspended in air if the gravitational force $F_g = mg$ acting downward on the drop is equal to the electrical force $F_e = qE$ acting upward.

  $qE = mg$

  $E = V/d$ $$q = \frac{mgd}{V}$$
- The terminal velocity is determined by timing the fall of the droplet over a measured distance.
- Minimum quantum charge is of electron i.e. 1.6×10^{-19}C

CAPACITOR & CAPACITANCE

Capacitor is a device used for ***storing electric charge*** *and electrical energy.*

- Charge stored by capacitor is given as; $Q = CV$

  Where C is **capacitance of** capacitor
- *Capacitance is defined as:*

  "Ability of a capacitor to store charge."

  OR

  "The ratio of charge stored to the potential difference between plates of capacitor."

  Mathematically,

  $C = Q/V$
- *SI unit of capacitance is* ***Farad.***
- **1 Farad** It is defined as:

  "The capacitance of a capacitor is one farad if a charge of one coulomb, given to one of the plates of a parallel plate capacitor, produces a potential difference of one volt between them"

  $1F = 1C/1V$
- *Capacitance of parallel plate capacitor with air between its plates is given as;*

  $C_{vac} = \epsilon_o A/d$

The above expression shows that:-

- As we increase the area of plate the capacitance will increase.
- Decreasing the distance between plates will increase the capacitance.

- Introducing a dielectric between the plates will increase the capacitance of the capacitor.
- *Capacitance of a parallel plate capacitor with dielectric between its plate* is given as;

$$C_{med} = \epsilon_r \epsilon_o A/d$$
$$= \epsilon_r C_{vac}$$
$$C_{med} > C_{vac}$$

Dielectric co-efficient or Dielectric constant

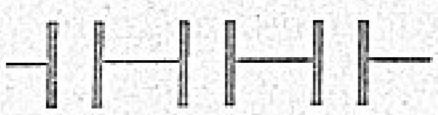
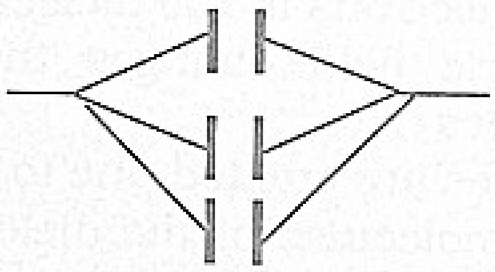
Definition: "The ration of the capacitance of a parallel plate capacitor with an insulating substance as medium between the plates to its capacitance with vacuum (or air) as medium between them".

$$\epsilon_r = \frac{C_{med}}{C_{vac}}$$

- *Charging of capacitor is due to induction phenomenon.*
- Old name of capacitor is condenser.
- *Types of capacitor*

1- Parallel plate capacitor
2- Spherical capacitor
3- Miniature capacitor
4- Tubular capacitor.
5- Paper capacitor
6- Electrolytic capacitor
7- Variable capacitor.

COMBINATIONS OF CAPACITORS

Series combination	***Parallel combination***
One path for current passage	*More than one paths for flow of current*
Same charging and discharging currents through each component	*Different charging and discharging currents depending on its capacitance*
Different potential difference across each component	*Same potential difference across each component.*
C_{eq} is smaller than the smallest capacitance in the circuit.	*C_{eq} is larger than the largest capacitance in the circuit.*
$1 / C_{eq} = \sum_{i=1}^{n} 1 / C_i$	$C_{eq} = \sum_{i=1}^{n} C_i$
	

POLARIZATION

*Polarization is a phenomenon of appearance of opposite charges on surface of a plate subjected to **electric field.***

- Polarized charges are called *induced charges*

- *Dipole* is a set of two equal and opposite charges separated by a small distance 'r.'

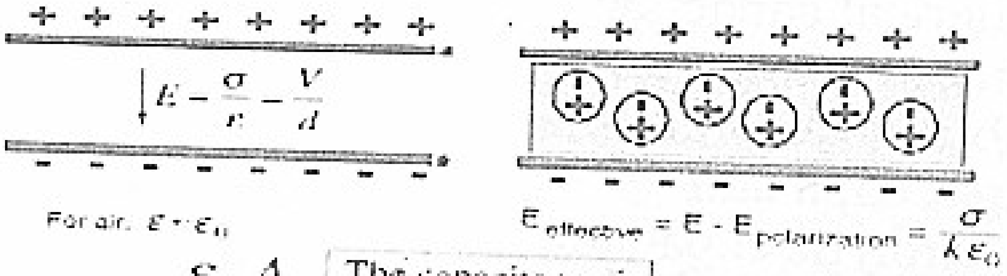
$+q$ ⟷ $-q$

- *Some substance are polar* i.e. they have **permanent dipoles** e.g. in NaCl, the end with Na ion is positive while that with **Cl** ion is **negative.**
- *Some substances are* ***non-polar*** i.e. they do not have **permanent dipole** e.g. plastic. *They become polarized* ***temporarily*** *when subjected to* ***external field.***
- *Polar molecules experience torque when subjected to uniform electric field but zero net force. In non-uniform electric field it* ***also experiences*** *net* ***force*** *in addition* ***to torque.***

DIELECTRICS

Insulator placed between two point charges is called ***dielectric.***

- *Dielectrics are* ***non-polar.***
- Dielectrics get polarized with opposite polarity to electric field.
- Molecular view of a polarized dielectric (in case of capacitors) is shown below;


$E = \frac{\sigma}{\varepsilon} = \frac{V}{d}$
For air, $\varepsilon = \varepsilon_0$
$E_{effective} = E - E_{polarization} = \frac{\sigma}{k\varepsilon_0}$

$$C = \frac{\varepsilon_0 A}{d}$$

The capacitance is increased by the factor k.

$$C = \frac{k\varepsilon_0 A}{d}$$

It shows that *a* ***static equilibrium*** *exists within the dielectric.*

- In physics, we represent dielectric by its ε_r (relative permittivity).

Effect of Dielectrics on Various Electrical Quantities

$F' = F / \epsilon_r$ (decreases)
$E' = E / \epsilon_r$ (decreases)
$V' = V / \epsilon_r$ (decreases)
$C' = C \epsilon_r$ (increases)

Do you know?

Value of ε_r for all dielectrics is greater than 1 except for air.

Polarization Of Dielectrics

- The electric polarization of dielectric increases the capacitance.
- The electrons in the dielectric (insulator) are bounded.
- Electric field changes the neutral position of negative and positive charges
- Dipoles are created due to separation of charges **+ve and –ve.**
- The molecules of the dielectric under the action of electric field become diploes and dielectric is polarized.
- *As $E = \sigma/\epsilon_o$, so E decreases due to* ***polarization of dielectric.***
- *Decrease in E decreases the* ***potential difference.***
- *As a result capacitance increases*

ENERGY STORED IN A CAPACITOR

- Charge on the plate of capacitor **possesses electrical potential energy** because of work done to deposit the charge on the plates.
- P.E = Energy on plate = $\frac{1}{2} qv$

  Energy in capacitor = $\frac{1}{2} CV^2 = \frac{1}{2} q^2/C$
- Energy is stored in electric field between the plates.
- Energy = $\frac{1}{2}[A\epsilon_r\epsilon_o/d]\,[Ed]^2$
- *Energy Density* =Energy/volume = $1/2\epsilon_r\epsilon_o E^2$

Do you know?

- *For D.C, capacitor behaves as open circuit*
- *For A.C, capacitor behaves as closed circuit.*

CHARGING AND DISCHARGING CAPACITOR

- Capacitors are charged and discharged slowly.
- *D.C supplies stores charges on the plate*
- A.C supplies does not store charge
- Charging and discharging time depends upon
- product of R & C
- ***Time constant***

  $t=RC$

  Its unit is 's' i.e. second.
- Time constant is defined as the time required by a capacitor to charge up to 0.63 times equilibrium charge on the capacitor.
- Charge reaches its equilibrium value **sooner** when time constant is smaller.
- Windshield wipers of car work by charging and discharging of capacitor.

MATHEMATICAL CONSIDERATIONS

- Time taken by radio wave from transmitter to radio set is ℓc^{-1} where 'ℓ' is distance between transmitter and radio set and 'C' is speed of light
- 1 eV = 16×10^{-19} J

  1 MeV = 10^6 eV = 1.6×10^{-13} J

  1 GeV = 10^9 eV = 1.6×10^{-10} J
- $\Delta U = q\,\Delta V$

  $\Delta W = q\,\Delta V$

  $1/2\,mV^2 = q\,\Delta V$
- $\sigma = Q/A$

PRACTICE EXERCISE

40 min Time Yourself

1. When we rub a glass rod with a silk cloth, then____________
   (a) glass rod acquires negative charge while silk acquires positive charge
   ~~(b)~~ glass rod acquires positive charge while silk acquires negative charges
   (c) both glass rod and silk acquire negative charge
   (d) both glass rod and silk acquire positive charge
2. If the distance between the two point charges become half, then force between them becomes ____________
   (a) double (b) half
   (c) four times. (d) remains same
   $F \propto \frac{1}{r^2}$ $\left(\frac{1}{2}\right)^2$ $\frac{1}{4}$
3. The minimum charge on any object cannot be less than____________
   (a) 1.6×10^{-19}C. (b) 3.2×10^{-19}C
   (c) 9.1×10^{9}C (d) no definite value exist
4. Why is positive charged object neutral by someone touching it
   (a) electrons flow from the object (b) electrons flow on to the object.
   (c) protons flow from the object (d) protons flow on the object
5. Electric force between two point charges in air or vacuum is F. If we replace air or vacuum by an insulator (dielectric) of relative permitivity ϵ_r, the force between the charges will.____________.
   (a) decrease.
   (b) increase
   (c) remain constant
   (d) depends upon composition of dielectric
   $F' = F/\epsilon_r$
6. Two charges are placed at a certain distance. If the magnitude of each charge is doubled, the force will become____________
   (a) 1/4th of its original value (b) 1/8th of its original value
   (c) 4 times of its original value. (d) 8 times of its original value
7. The force per unit charge is known as ____________
   (a) electric flux (b) electric intensity.
   (c) electric potential (d) all of above are same
8. An electric field can deflect ____________
   (a) neutrons (b) γ-rays
   (c) both (d) none.
9. An electric charge at rest produces____________
   (a) only a magnetic field
   (b) only an electric field.
   (c) neither electric field nor magnetic field
   (d) both electric and magnetic fields
10. If a unit positive charge is placed in air then the flux coming out of it is
    (a) $4\pi\epsilon_0$ (b) ϵ_0^{-1}. $1/\epsilon$
    (c) ϵ_0 (d) $4\pi/\epsilon_0$
11. Electric potential of the earth is taken as zero because the earth is a good
    (a) insulator. (b) conductor
    (c) semiconductor (d) super conductor

12. Electric flux linked with a surface will be maximum when ____________
(a) the surface is held parallel to the electric field
(b) the surface is held perpendicular to the electric field
(c) the surface makes an angle of 45° with the field
(d) all of the above

13. The unit of ε_r
(a) $Nm^{-1}A^{-(a)}$ (b) $N^{-1}m^{1}C^{2}$
(c) $Nm^{2}C^{2}$ (d) No unit

$F = \frac{1}{4\pi\varepsilon_o} \times \frac{q^2}{r^2}$

$\varepsilon_o = NC^2m^{-2}$

14. The electric lines of force are ____________
(a) imaginary
(b) physically existing every where
(c) physically existing near the charges
(d) depends upon case

15. Tick the correct statement
(a) the electric lines of force have no physical existence
(b) they expand laterally and contract longitudinally
(c) they do not cross each other and group together in dielectric
✓(d) all the above statements are true

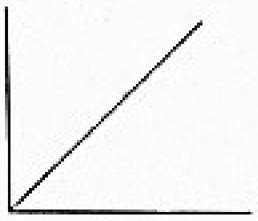
16. A capacitor of capacitance C has charge Q and stored energy is W. if the charge is increase to 2Q. the stored energy will be
(a) W/4 (b) W/2
(c) 2W (d) 4W

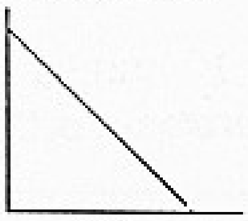
$q = CV$

$W = \frac{1}{2}qV$

17. Two similar charges each of one coulomb placed in air one meter apart repel each other with a force ____________
(a) $9x10^{9}N$ (b) $9.2x10^{4}N$
(c) $9x10^{-9}N$ (d) $9x10^{7}N$

18. The variation of electric potential due to a point charge with distance is represented by the graph


(a)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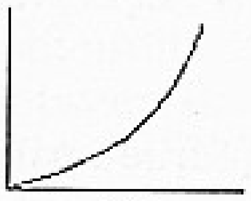
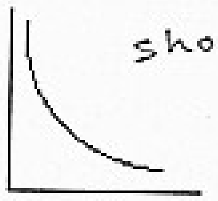

(c)


(d)

showing inverse relation.

19. A hollow metallic sphere of 8cm diameter is charged with $4x10^{-8}C$. The potential on its surface will be ____________
(a) 900 volts (b) 9000 volts
(c) 90 volts (d) zero

$V = \frac{Kq}{r}$

20. The metallic spheres A and B of radii 2m and 4m respectively carry the same charge $4x10^{-8}C$. If the spheres are connected by a copper wire, ____________
(a) charge will flow from A to B (b) charge will flow from B to A
(c) no flow of charge will occur (d) both 'a' and 'b' are possible

higher charge density ⟶ lower charge density

21. When body is negatively charged by electrostatic induction, its mass will
(a) increases (b) decreases
(c) remain same (d) none of these

22. Equipotential planes are ____________
(a) parallel to one another (b) non-parallel to one another
(c) intersecting (d) circular

$E = qV$

23. The value of the capacitance depends upon the__________

(a) voltage applied (b) thickness of the capacitor plates
(c) geometry of the capacitor (d) density of the capacitor plates

24. A 25eV electron has a speed of __________

(a) 2×10^6 m/sec (b) 3×10^6 m/sec
(c) 5×10^6 m/sec (d) 4×10^6 m/sec

$qV = K.E$

25 A 5 μF capacitor has a potential difference across its plates of 200 volts. The charge on the capacitor is __________

(a) 2.5×10^{-8} C (b) 10^{-3} C
(c) 10^3 C (d) 4×10^3 C

$= 5 \times 10^{-6} \times 200$
$= 1 \times 10^{-3}$

26 If a 10 F capacitor is to have an energy content of 20J, it must be placed across a potential difference of __________

(a) 4 volts (b) 9 volts
(c) 2 volts (d) 1 vol

$\frac{1}{2} \frac{5}{10} V^2 = 2$

27 Equivalent capacitance is greater than individual capacitances in__________

(a) series combination
(b) parallel combination
(c) both series and parallel combinations
(d) none of above

28. If the distance between the plates of parallel plates condenser is increased, its potential will

(a) Remain same (b) increase ✓
(c) decrease ✗ (d) decreases exponentially

$E = \frac{V}{d}$

29. The number of electrons in one coulomb charge is equal to __________

(a) 6.2×10^{18} (b) 1.6×10^{-19}
(c) 6.2×10^{21} (d) 1.6×10^{-27}

$1e = 1.6 \times 10^{-19}$

$\frac{1}{1.6 \times 10^{-19}} =$

30. With what speed electric field travels

(a) $2 \times 10^6 \text{ms}^{-1}$ (b) $3 \times 10^8 \text{ms}^{-1}$
(c) $1.5 \times 10^6 \text{ms}^{-1}$ (d) 330ms^{-1}

31. SI unit of permitivity of free space is __________

(a) Nm^2C^2 (b) $\text{N}^{-1}\text{mC}^{-2}$
(c) NmC^{-1} (d) $\text{N}^{-1}\text{m}^{-2}\text{C}^2$

$F = \frac{1}{\varepsilon_o} \times \frac{q^2}{r^2}$

32. Value of ε_r for various dielectrics is always __________

(a) less than unity (b) equal to unit
(c) larger than unit (d) no hard and fast rule

33. Electric intensity at infinite distance from the point charge is__________

(a) Zero (b) infinite
(c) positive (d) negative

34. Which one of the following can be taken as the measure of electric intensity?

(a) F/A (b) ϕ/A ✓
(c) $\phi\varepsilon_o$/A (d) $q/\varepsilon_o A$

$\phi = E.A$

35. Electric flux due to a point charge +q is__________

(a) $1/4\pi\varepsilon_o \cdot q/r$ (b) q/ε_o ✓
(c) $1/4\pi\varepsilon_o \cdot q/r^2$ (d) $4\pi\varepsilon_o$

36. N/C= __________

(a) V/A (b) J/V
(c) V/m ✓ (d) A/m

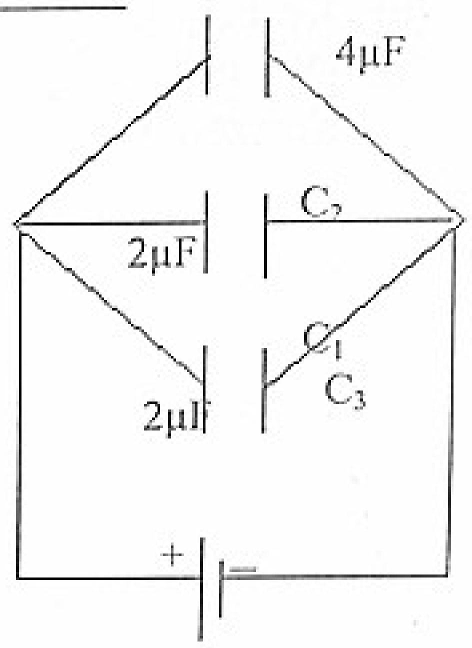
$\frac{F}{q} = E$

37. A charge of 0.10C accelerated through a potential difference of 1000V acquires kinetic energy ____________
(a) 200J
(b) 10J ✓
(c) 1000J
(d) 100 eV

V = 1000
q = 0.10
U = qV

38. A capacitor is a perfect insulator for ________
(a) direct current
(b) alternating current
(c) both for the direct and alternating current
(d) none of above

39. Three capacitors C_1, C_2 and C_3 are connected in parallel as in the Fig. The equivalent capacitance will be ______________



(a) 8μF
(b) 0.8μF
(c) 1μF
(d) 16μF

40. In a charged capacitor the energy resides in ______________
(a) magnetic field
(b) electric field
(c) nuclear field
(d) gravitational field

41. For what value of θ, the electric flux has average value of those of extreme values?
(a) 60° ✓
(b) 45° ✗
(c) 90°
(d) 0°

42. Two plates are 2cm apart. If a potential difference of 10volts is applied between them, the electric field between the plates will be
(a) 20N/C
(b) 500 N/C
(c) 5 N/C
(d) 250 N/C

$E = V/d = \frac{10 \times 10^2}{2} = 500$

43. Work done in moving a point charge from one point to another point of equipotential surface is __________
(a) $\Delta W = q\Delta V$
(b) $\Delta W = F\Delta r$
(c) zero
(d) $W = 1/4\pi\epsilon_0 \Delta V$

44. Selenium becomes a conductor in light so it behaves like __________
(a) Semiconductor
(b) Photoconductor
(c) Light emitting diode
(d) Capacitor

45. The unit of potential gradient
(a) Volt/meter
(b) Volt x meter
(c) C/m
(d) Volt/ampere

46. The black powder used in photocopier is
(a) Heart of machine
(b) Called Toner
(c) Gutter
(d) None is

47. Electric field can deflet by
(a) X-rays
(b) neutrons
(c) gamma-rays
(d) beta-rays

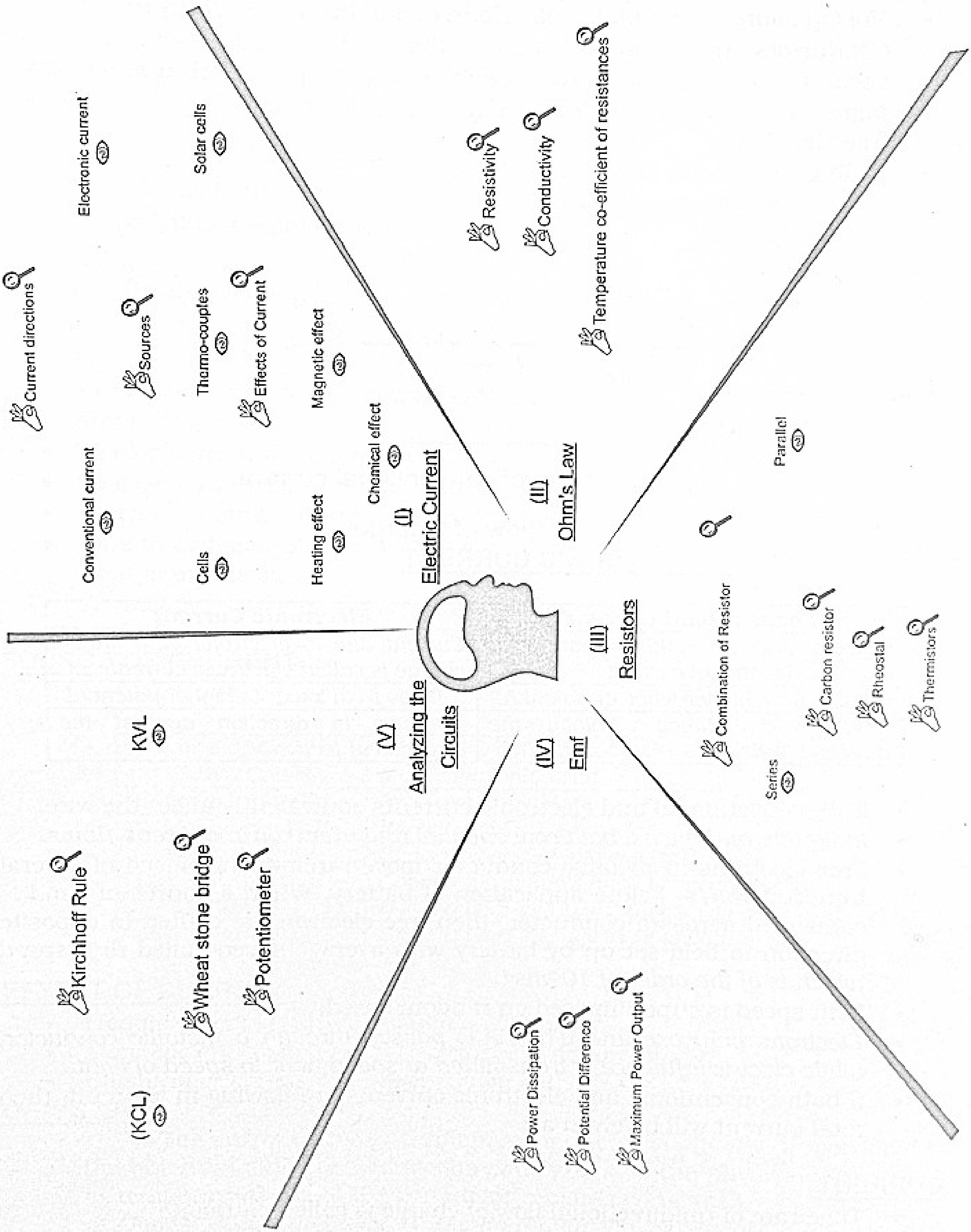
48. If mica sheet is placed between the plates of a capacitor, the capacity______
(a) increases
(b) decreases
(c) increases then decreases
(d) decreases then increases

49. The dielectric constant k of an insulator can be
(a) -1
(b) 0.5
(c) 0
(d) 5

50. According to Coulomb's law, the electrostatic force between two charges is
(a) Inversely proportional to the product of the charges
(b) Inversely proportional to the square of the distance between the charges
(c) Directly proportional to the cube of the distance between the charges
(d) Directly proportional to the product of the two charges and also the distance between them

Chapter 13

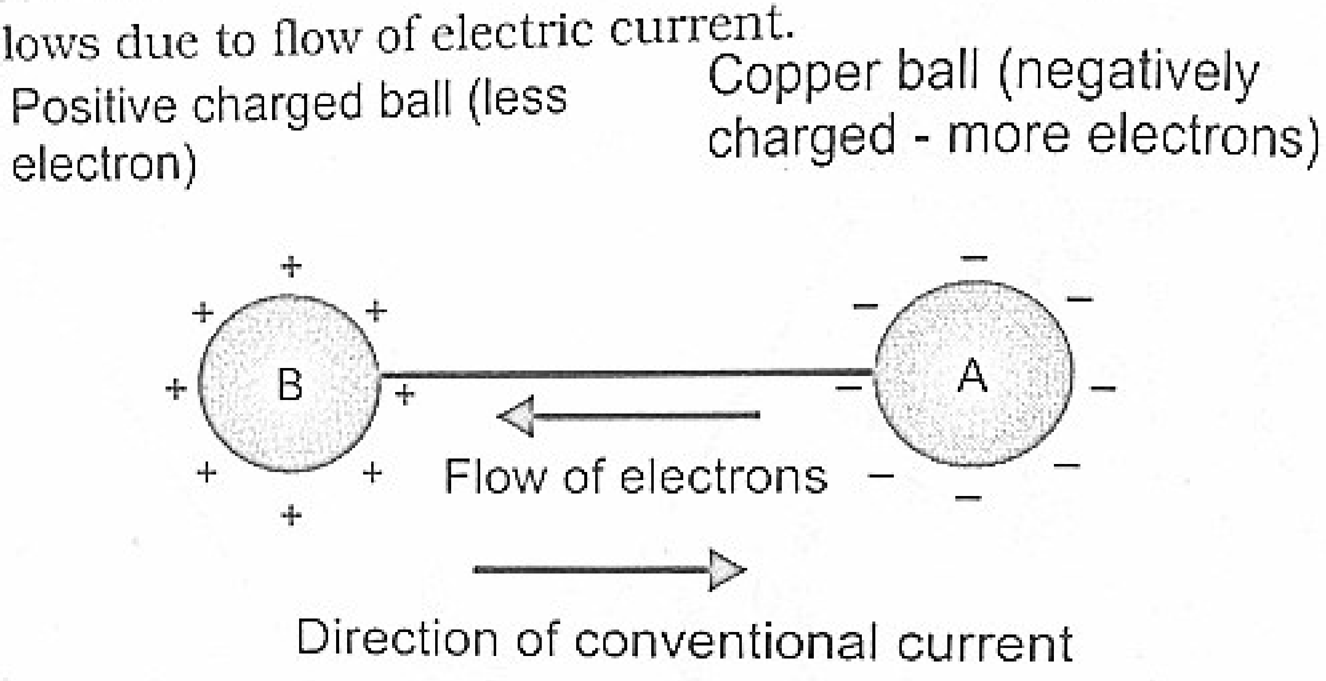
CURRENT ELECTRICITY



Chapter 13

Current Electricity

- *Current electricity* or ***electrodynamics*** is the branch of physics that deals with charges in motion.
- *Moving charge associates both* ***electric*** *and* ***magnetic field*** *with it.*
- *Conductors* are those substances that conduct **electricity** and **heat** because they **are rich** in **free electrons**, called **conduction electrons**.
- *Insulator* do not conduct electricity and heat because they do not contain free electrons
- Bulb glows due to flow of electric current.


Positive charged ball (less electron)
Copper ball (negatively charged - more electrons)
B
A
Flow of electrons
Direction of conventional current

Flow of Charges

CONVENTIONAL & ELECTRONIC CURRENT

Conventional Current	*Electronic Current*
Current due to positive charges is called conventional current	*Current due to electrons or negative charge is called electronic current.*
It flows from higher to lower potential	*It flows from lower to higher potential.*
It flows in direction along the direction of field.	*It flows in direction against the direction of field.*

- Both conventional and electronic currents equivalently affect the wire.
- *In liquids and gases, both conventional and* ***electronic current flows.***
- Free electrons in metallic conductor move randomly at speed of several **hundred km/s,** before application of battery. When a source of e.m.f is connected across a conductor, then free electron are drifted in opposite direction to field set up by battery with average speed called *drift speed which is of the order of* $10^{-3} ms^{-1}$.
- Drift speed is superimposed on random speed.
- *Electrons only oscillate when A.C passes through a metallic conductor, while electric influence is transmitted at speed near to speed of light.*
- If both conventional and electronic currents are flowing in a circuit, then total current will be given as;

$$I_{total} = I_{+ve} + I_{-ve}$$

CURRENT

- Time rate of unidirectional flow of charge is called *current.*

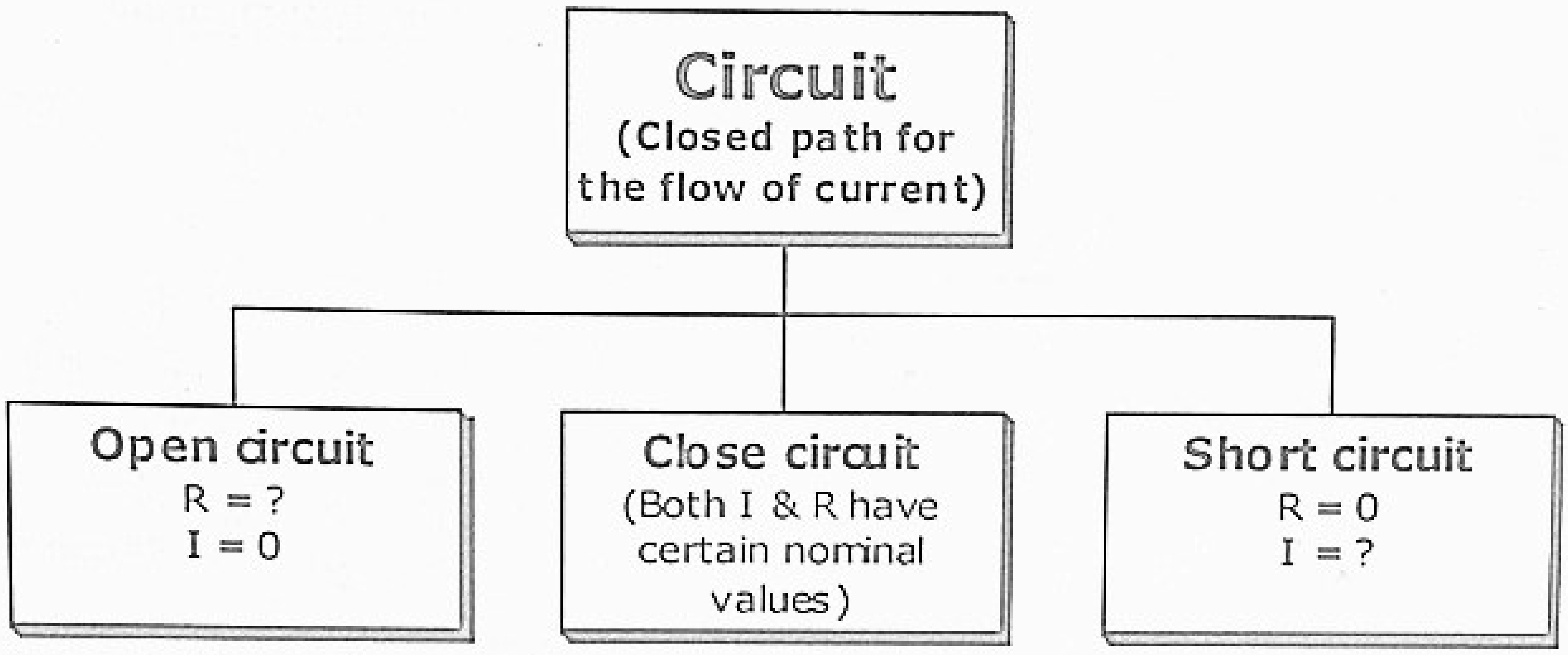
$$I = Q / t$$

- *SI unit of current is ampere* and it is defined as:

"1A current is that which is caused by 1C charge flowing in 1 sec through any cross-section of a conductor."

- *Current density* is the current flowing per unit area.

$J = I / A$


Circuit
(Closed path for the flow of current)
Open circuit
R = ?
I = 0
Close circuit
(Both I & R have certain nominal values)
Short circuit
R = 0
I = ?

- *In metallic conductors, the charge carriers are electrons.*
- *In electrolytes, the charge carriers and ions.*
- In gases, the charge carriers are electrons and ions.
- Current is only produced where there is a potential difference
- Due to collision of free electrons under the action of potential difference, heat is produced
- A steady current flows when a constant potential difference is maintained.

SOURCE OF CURRENT

Cells convert chemical energy into electrical energy.

Name of Device	***Notable Feature***
Dry Cell	*Most commonly used*
Primary Cell	*Non- rechargeable*
Secondary Cell	*Rechargeable*
Voltaic Cell	*Convert chemical into electrical energy*
Electric Generator	*Convert mechanical into electrical energy*
Solar Cell	*Convert light into electrical energy*
Thermocouple	*Convert heat into electrical energy*

EFFECT OF CURRENT

- *Heating effect i.e.* $H = I^2Rt$ such as in heater.
- *Magnetic effect* such as in transformer, motors etc.
- *Chemical effect* e.g. Cu^{++} deposits on cathode.

OHM'S LAW

The current flowing through a conductor is directly proportional to the potential difference across its ends provided the physical states such as temperature etc. of the conductor remains constant?

Ohm's law expresses a relation between potential difference and current as given below:

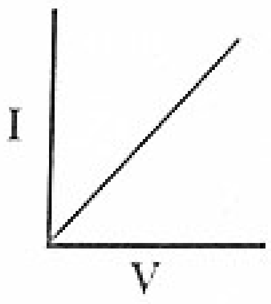
$V = IR$

Where R is known as resistance measured in ohms

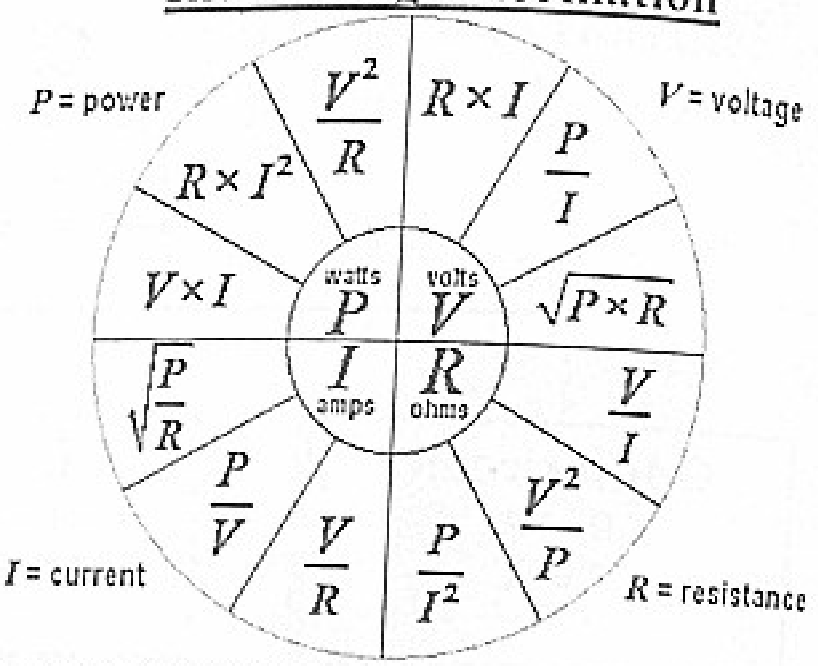
- Microscopic form of Ohm's law is given as:

$J = \sigma E$ Where σ is conductivity

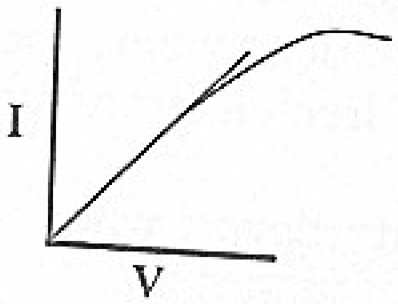
- The metallic conductor that obeys Ohm's law is called ***ohmic conductor***. Its V ~ I graph is a straight line as given below:



Interesting Information



- The conductor that does not obey Ohm's law is called ***non-ohmic conductors.*** Its V~I graph is not a straight line



RESISTANCE, RESISTIVITY & CONDUCTIVITY

Opposition or hindrance to flow of electron is called ***Resistance***

$R = V/I$

- *Its SI unit is ohm (Ω)* that is defined as:

"If 1V potential difference across a conductor produces 1A current then, resistance will be 1Ω."

Do you know?

Metallic conductors deviate from their ohmic to non-ohmic behavior when subjected to high potential difference.

- *Resistance arises due to collision between* ***current carriers*** *and* ***vibrating*** *ions.*
- Resistance of conductor depends on following factors:
  1- $R \propto L$
  2- $R \propto 1/A$
  3- $R \propto T$ (except semi-conductors)
  4- Nature of material
- *Resistivity* is a resistance of 1 m cube of a substance. It is given as;

$\rho = RA/L$

Where ρ is called resistivity

- We can say that,

$\rho = R$ if $A = 1m^2$

$L = 1m$

Its SI unit is Ω-m.

- Reciprocal of resistivity is called *conductivity*

  $\sigma = 1 / \rho$

  Its SI unit is (Ω-m)$^{-1}$

- R increases with rise of temperature because of increase in **amplitudes of vibration of ions the collision of electrons and ions increases.**
- *Conductance* = 1/Resistance

  *Its **SI unit** is **mho or siemen**.*

TEMPERATURE CO-EFFICIENT OF RESISTANCE AND RESISTIVITY

- Fractional change in resistance per kelvin change in temperature is called *temperature co-efficient of resistance.* It is given as;

$$\alpha = R_T - R_o / R_o \Delta T$$
$$= \Delta R / R_o \Delta T$$
or
$$R_T = R_o (1 + \alpha \Delta T)$$

- Fractional change in resistivity per degree change in temperature is called ***temperature co-efficient of resistivity***

$$\alpha = \rho_T - \rho_o / \rho_o \Delta T$$
$$= \Delta\rho / \rho_o \Delta T$$
or
$$\rho_T = \rho_o (1 + \alpha \Delta T)$$

- *SI unit of co-efficient of resistance or resistivity is K^{-1}*
- Temperature co-efficient of conductors is helpful in differentiating them.
- If two conductors (e.g. iron and platinum) have equal resistivity, even then they can be differentiated, by measuring their temperature co-efficient of resistivity.

Do you know?

Resistivity of semiconductors decreases with increase of temperature, so they have negative temperature coefficients e.g. Germanium and Silicon etc.

SUPERCONDUCTIVITY

- When temperature of conductor falls, the amplitude of vibrations decreases and hence resistance and resistivity both decrease.
- *It is not possible to make resistance or resistivity equal to zero by falling temperature because ions retain their oscillations even at 0K.*
- Metallic conductors that show remarkable decrease in their resistance with fall of temperature are called *superconductors.*
- The temperature at which a super conductor almost looses its all resistance is called *critical temperature.* T_c denotes it.
- Major problem with superconductor is that they loose superconductivity at room temperature
- Virtue of superconductivity is to save electrical energy in future

TOP Study

- Electrical energy would pass with zero loss through a super conductor.

For your information

- In 1986, Bednortz and Muller discovered some ceramics that show superconductivity at 30K.
- Presently some ceramic materials have been discovered that show super conductivity at 125K

- *Superconductivity is a quantum mechanical phenomenon*

COMBINATIONS OF RESISTANCES

Series combination	*Parallel combination*
One path for current passage	*More than one paths for flow of current*
Same current through each component	*Different current through each component depending on its resistance*
Different potential difference across each component	*Same potential difference across each component.*
R_{eq} is larger than the largest resistance in the circuit	*R_{eq} is smaller than the smallest resistance in the circuit.*
$R_{eq} = \sum_{i=1}^{n} R_i$	$\frac{1}{R_{eq}} = \sum_{i=1}^{n} \frac{1}{R_i}$

In all combination of resistors, law of conservation of energy and charge apply.

JOULE THOMSON'S EFFECT & POWER DISSIPATION

- When current flows through conductors, then a part of energy of current carriers is transferred to ions on their way, due to which their amplitudes of vibration increases which result in rise of temperature. The above phenomenon is known as *Joule Thomson's effect.* Hence electrical energy is wasted that is given as;

$$W = QV$$
$$P = W/t \qquad = QV/t$$
$$P = IV$$
$$P = I^2R$$
$$P = V^2/R$$

Where P represents the power dissipation.

- *Heat produced due to power dissipation* is given as;

$$H = P \times t$$
$$= I^2 R t$$
$$= V I t$$
$$= V^2 t / R$$

- If 1J electrical energy is waste per second, then power dissipated will be 1 watt.

$$1 \text{ watt} = 1J / 1s$$

- *Kilowatt-hours* is a commercial unit of **electrical energy.** It is defined as: "When a power of 1KW is maintained through a circuit for 1 hour, then heat energy dissipated is 1KWh."

$$1\ KWh = 1000\ W \times 3600\ sec$$
$$= 3.6 \times 10^6\ J$$
$$1\ J = 2.77 \times 10^{-7}\ KWh$$

EMF:

emf of a source in defined as potential difference between its out put terminals when either its internal resistance ***is zero or no current is drawn from it.***

- When charge carriers flow through a conductor, they loose their electrical K.E. In doing work against resistance, loss of energy is compensated by source of **emf at same rate.**
- Every source of emf has its own resistance called ***internal resistance.***
- Smaller is internal resistance of a battery, better it will be a source of emf
- **Terminal potential** difference is a voltage between out put terminals of a source of emf when current is **drawn from it.**
- We can relate emf (ϵ), terminal potential (V_t) and internal resistance(r) by the following equation:

$$\epsilon = V_t + Ir$$
$$V_t = \epsilon - Ir$$

Point to remember

There are few relation for comparing V_t and ϵ-

1- $V_t = \epsilon$ *if* $I = 0$ *(open circuit)*

2- $V_t = \epsilon$ *if* $r = 0$

3- $V_t < \epsilon$ *by a factor* Ir *except when one battery charges the other*

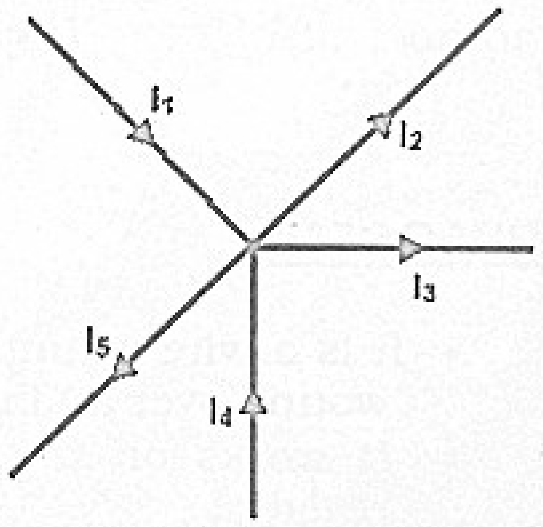
emf is "cause" & potential difference is its "effect".

Maximum power is delivered when $r = R$

KIRCHHOFF'S LAWS

Kirchhoff's Current Law (KCL)

The sum of all the currents flowing towards a point in equal to the sum of all the currents flowing away from the point.



Therefore, $I_1 + I_4 = I_2 + I_3 + I_5$

Hence, $I_1 + I_4 - I_2 - I_3 - I_5 = 0$

or $SI = 0$

(Sum of currents entering a junction = Sum of currents leaving the junction)

This rule is based on the fact that charge

Kirchhoff's Voltage Law (KVL)

The algebric sum of potential changes in a closed circuit is zero.

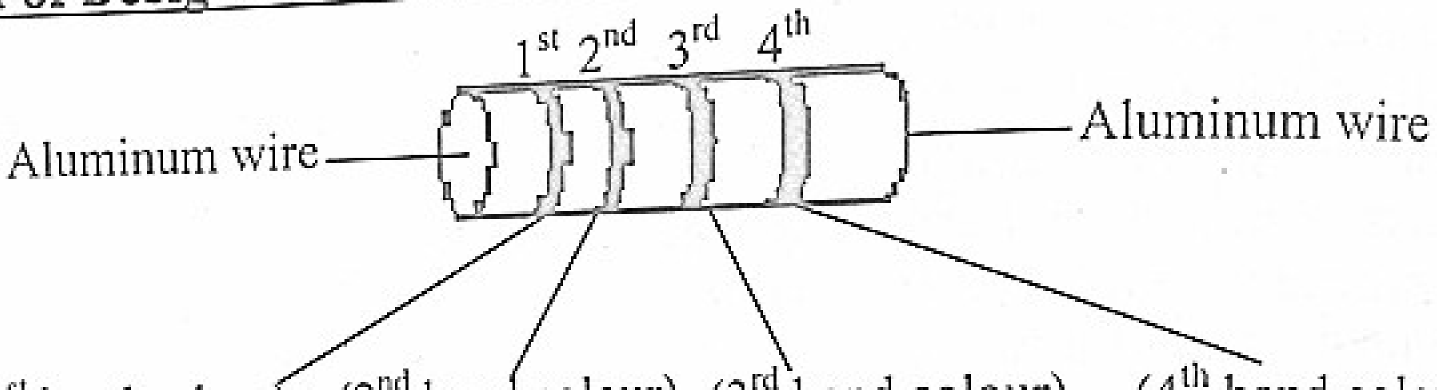
- Loop is a branch of circuit that originates and terminates at the same point.

COLOUR CODE FOR CARBON RESISTORS

B	B	R	O	Y	G	B	V	G	W
0	1	2	3	4	5	6	7	8	9

The resistances are of fixed values but highly temperature dependent.

Method of Designation of Numeric value to a colour coded carbon resistor

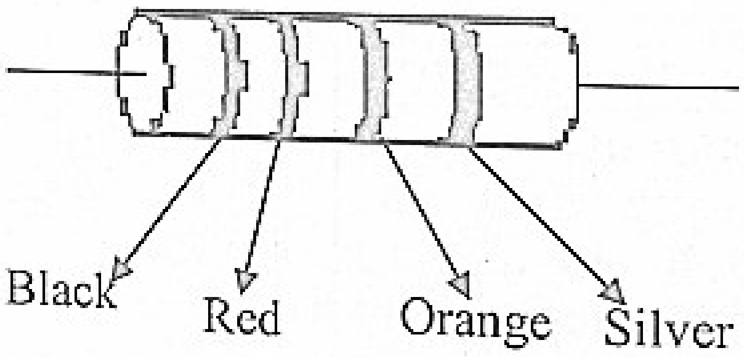


(1st band colour)	(2nd band colour)	(3rd band colour)	(4th band colour)
indicate the 1st digit of the numeric value of resistor.	indicate the 2nd digit of the numeric value.	indicate the number of zeros in the numeric value.	specify the tolerance for silver ±10% for gold ±5%. no fourth band ±20%

Tolerance

By tolerance, we mean the possible variation from the marked value.

For example



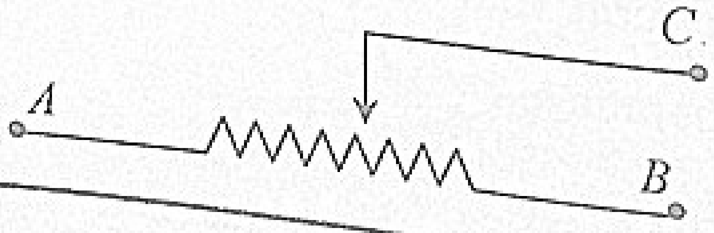
The value of resistance is $R = \underbrace{0}_{\text{1st digit}}\underbrace{2}_{\text{2nd digit}}\underbrace{\boxed{000}}_{\text{Number of zeros}} \pm \overset{\text{Tolerance}}{\boxed{10\%}}\ \Omega$

RHEOSTAT

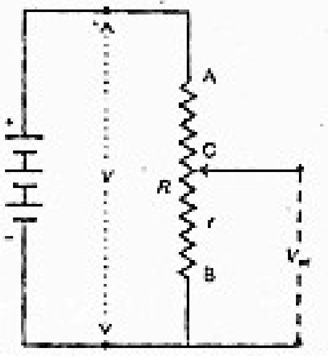
- It is a wire wound variable resistance consisting of bare magnesium wire wound over an insulating cylinder.
- It works on the principle that changes in length effects the value of resistor.

R×ℓ

Symbol in electrical circuits is



Consider the circuit



Use of rheostat as potential divider

- Rheostat is used as **variable resistance** and **potential divider** just like dimmers in electric fans and volume control knob in radio set.

THERMISTORS

Features

- ⇒ Non-metallic resistors
- ⇒ Highly heat sensitive resistor
- ⇒ Negative temperature coefficient of resistance i.e
  Resistance decreases with increase of temperature
- ⇒ Thermistors with positive temperature coefficient are also available

> **Do you know?**
>
> *The thermistors with positive temperature coefficients are also available.*

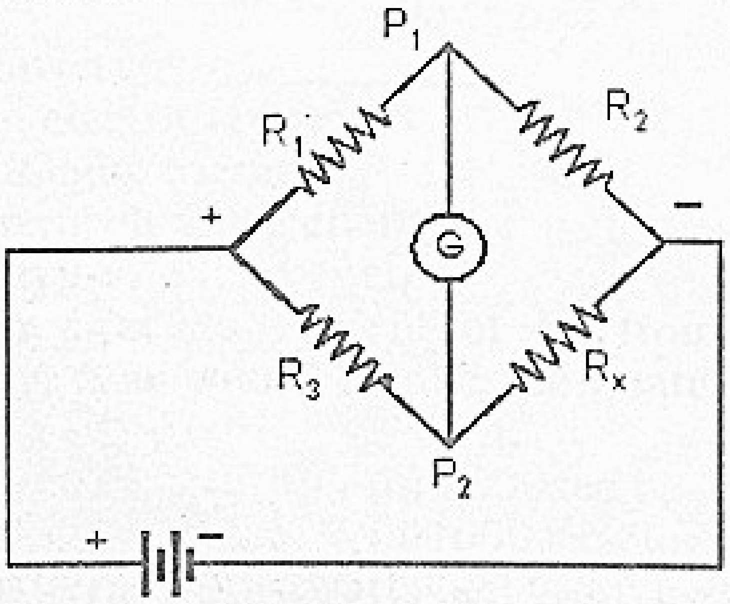
Uses

⇒ for very accurate measurement of very low temperature near about 10K or –263°C.

⇒ as heat sensors because it converts changes of temperature into electrical voltage.

WHEATSTONE BRIDGE (W.S.B)

- W.S.B consists of 4 resistances R_1, R_2, R_3 and R_4 connected in loop or mesh of certain pattern.



- W.S.B is an accurate measuring instrument of resistance up to two decimal place.
- WSB is balanced when its galvanometer shows no deflection even when its keys are closed.

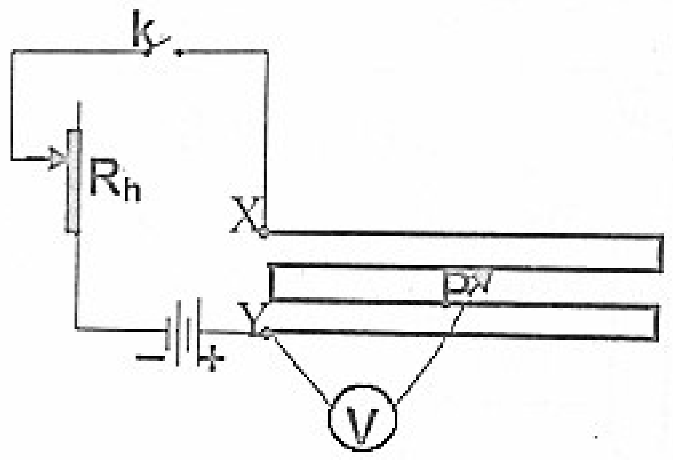
- *Condition for balanced bridge is that current through galvanometer is zero. Voltage at galvanometer will be equal.*
- ***Principle of Whetstone bridge***

$$R_1/R_2 = R_3/R_4$$

- Unknown resistance is placed at R_3 or R_4.
- Practical form of Whetstone Bridge is **post office box** and **slide Wire Bridge** that is also called Meter Bridge.

POTENTIOMETER

is a device which is used to compare and find unknown emfs in a circuit without drawing any current from the circuit.



- ***Uses***
  - ⇒ Accurate measurement of potential difference
  - ⇒ Measurement of emf of a battery
  - ⇒ Comparing emf's of batteries
  - ⇒ Internal resistance of a cell
- Wire of potentiometer is **4m long**, made of high resistance wire **(eureka)**
- ***Principle of potentiometer:***

  Voltage across any length of a wire of uniform area of cross section is directly proportional to its length when a constant current flows through it i.e. $v \propto l$ *and current is* $I = E/R$
- The ratio of the emf of two cells is equal to ratio of the **balancing lengths** i.e.

$$E_1/E_2 = l_1/l_2$$

PRACTICE EXERCISE

30 mins Time Yourself

(1) The current through a metallic conductor is due to the motion of ____________

[✓ (a)free electrons] (b)protons
(c)neutrons (d)still under controversy

(2) Resistance of a conductor depends upon ________________

(a)nature of conductor (b)dimension of conductor
(c)physical state of the conductor [✓ (d)all of above]

(3) A wire having very high value of conductance is said to be ____________

[✓ (a)very good conductor] (b)moderately good conductor
(c)an insulator (d)no specific criterion available

(4) A wire of uniform area of cross-section 'A' length 'L' and resistance R is cut into two parts. Resistivity of each part ________________

[✓ (a)remains the same] (b)is doubled
(c)is halved (d)becomes zero

(5) Production of heat due to an electric current flowing through a conductor is given by______________

(a)Joule effect [✓ (b)Joule Thomson's effect]
(c)Compton's effect (d)Feed back effect

(6) When same current passes for same time through a thick and thin wire _______________

(a)more heat is produced in thick wire
[✓ (b)more heat is produced in thin wire]
(c)no heat is produced in wire
(dequal heat is produced in thick and thin wire

(7) When a current of 1A flows for 5 sec through the lamp, 120W of power are used. How much charge flows through the lamp

I, T, P
Q = IT =
Q I = Q/T

(a)10C (b)24C
(c)30C (d)60C

(8) One kilowatt hour is the amount of energy delivered during _____________

(a)one second (b)one day
(c)one minute [✓ (d)one hour]

(9) Thermocouples convert______________

[✓ (a)heat energy into electrical energy]
(b)heat energy into light energy
(c)heat energy into mechanical energy
(d)mechanical energy into heat energy

(10) An electric heater takes a current of 4A from a 250V supply when operating normally, how would it take the heater to convert 400000J of electrical energy

$H = I^2RT$
$H = VIT$

[✓ (a)400sec] (b) 1000sec
(c)4000sec (d)1600sec

(11) An immersion heater of 400 watts kept on for 5 hours will consume electrical power of _____

$P = VI$
$P =$ $H = PT$

(a)2KWh (b)20KWh
(c)6KWh (d)12KWh

(12) Resistance of a super conductor is ____________

(a)finite
(b)infinite
(c)zero
(d)changes with every conductor

(13) Resistance of an ideal insulator is ____________

(a)infinite
(b)zero
(c)finite
(d)depends upon nature

(14) Which of the following describe the emf of a cell

(a) the difference in energy between that needed to drive unit charge through the load resistors and through cell
(b) the energy used to drive the unit charge through all load resistors in the circuits
(c) the energy used to drive the unit charge through the resistance of the cell
(d) the total energy used to drive unit charge round complete circuit

(15) Reciprocal of resistivity is called ____________

(a)resistance
(b)inductance
(c)conductivity
(d)flexibility

(16) When 2Ω, 4Ω and 6Ω resistor are connected in parallel, their resultant equivalent resistance will be____________

6+3+2 = 11/
12

(a)12Ω
(b)11/12Ω
(c)12/11Ω
(d)data is insufficient

(17) Circuit which gives continuously varying potential is called ____________

(a)complex network
(b)wheat stone bridge
(c)potential divider
(d)all of above

(18) Internal resistance is the resistance offered by ____________

(a)source of e.m.f
(b)conductor
(c)resistor
(d)capacitor

(19) There are three bulbs of 60W, 100W and 200W which bulb has thickest filament.

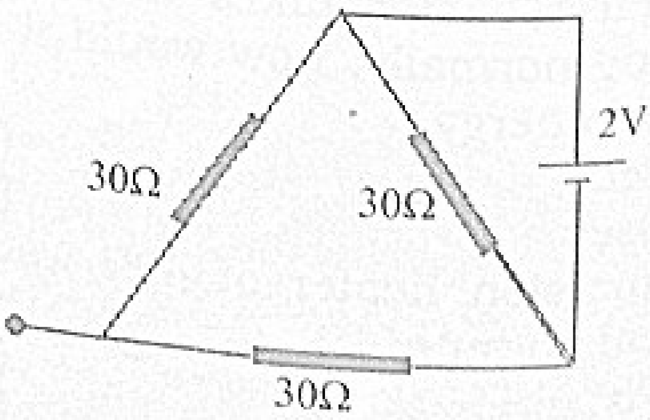
(a)100W
(b)200W
(c)60W
(d)all

(20) What can be used as the unit of energy

(a)watt x second
(b)volt x meter
(c)volt per coulomb
(d)Newton per meter

(21) The current in the circuit shown in figure - What will be the current in the circuit?

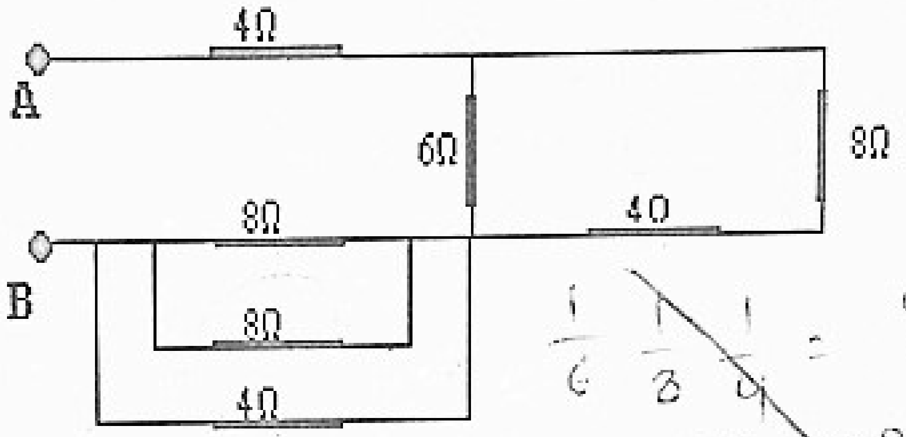
(a)1/45A
(b)1/10A
(c)1/5A
(d)5A



2 | 6-8-4
2 | 3-4-2

(22) Resistance between points A and B in the circuit shown in figure is ________

(a)4Ω
(b)6Ω
(c)10Ω ✓
(d)8Ω



$\frac{1}{6}\ \frac{1}{8}\ \frac{1}{4} = \frac{4+3+6}{24} = \frac{13}{24}$

$\frac{24}{13}$

$\frac{24}{13} + 8\quad \frac{24+312}{13}$

(23) What is used in a circuit to allow current in one direction only
(a)fuse (b)diode ✓
(c)ammeter (d)relay

(24) Resistance of a wire on increasing its temperature will________
(a)increase with rise in temperature ✓
(b)decrease with rise in temperature
(c)will remain same
(d)depends upon altitude of experimentation

(25) Specific resistance of a wire________
(a)will depend on its length
(b)will depend on its radius
(c)will depend on the type of material of the wire
(d)will depend on none of the above

(26) An electric iron is marked 20 volts 500W. The units consumed by it in using if for 24 hours will be ________
(a)12 (b)24
(c)5 (d)1100

$P = VI$

(27) A What is measured by the energy dissipated when a source drives a unit charge round complete circuit
(a) electromotive force (b) power
(c) resistance (d) potential difference

(28) In liquids and gases, the current is due to the motion ________
(a)negative charges
(b)positive charges
(c)both negative and positive charges
(d)neutral particles

(29) A 100W ,200V bulb is connected to a 160V supply. The actual power consumption would be
(a)64W (b)72W
(c)100W (d)90W

(30) The graphical representation of Ohm's law is ________
(a)hyperbola (b)ellipse
(c)parabola (d)straight line

(31) SI unit of resistivity is________
(a)Ω-m² (b)(Ω-m)⁻¹
(c)Ω-m (d(Ω-m)⁻¹

$\rho \frac{A}{A} = \frac{RA}{L} = \Omega m$

(32) The lower part of a cloud has positive. The cloud discharges in flash of lightning, in which direction do electrons and conventional current flow

	Electron flow	Conventional current
a	Downwards	downwards
[✓ b]	Upwards	Downwards
c	downwards	upwards
d	upwards	upwards

(33) The resistance of a conductor at absolute zero (0K) is__________

(a) zero almost   (b) infinite almost

(c) no prediction at all   (d) may increase or decrease

(34) Why should a resistance be introduced in a circuit in series deliberately?

(a)to increase current   (b)to decrease current

(c)to control current   (d)just to give a good look to circuit.

(35) Electrical energy is measured in__________

(a)watt   (b)horse power

(c)kilo watt   [✓ (d)kilowatt hour]

(36) Resistances of 12ohm, 10ohm and 8ohm are connected in parallel to a battery of 10V, the current in 10 ohm resistor is

(a)2A   (b)100A

(c)1A   (d)0.5A

V=IR

I=V/R = 10/12×10 =

(37) Electrical energy is converted to heat at the rate of __________

(a)IRt   [✓ (b)I^2R]

(c)I^2Rt (d)VIt

(38) Which one of the following bulbs has the least resistance?

(a)100 watt   (b)200 watt

[✓ (c)300 watt]   (d)60 watt

(39) A fuse is placed in series with the circuit to protect against __________

(a)high power   (b)high voltage

(c)high current   (d)over heating

(40) If 1 ampere current flows through 2m long conductor, the charge flow through it in 1 hour will be__________

(a)3600C   (b)7200C

(c)1C   (d)2C

L=2m

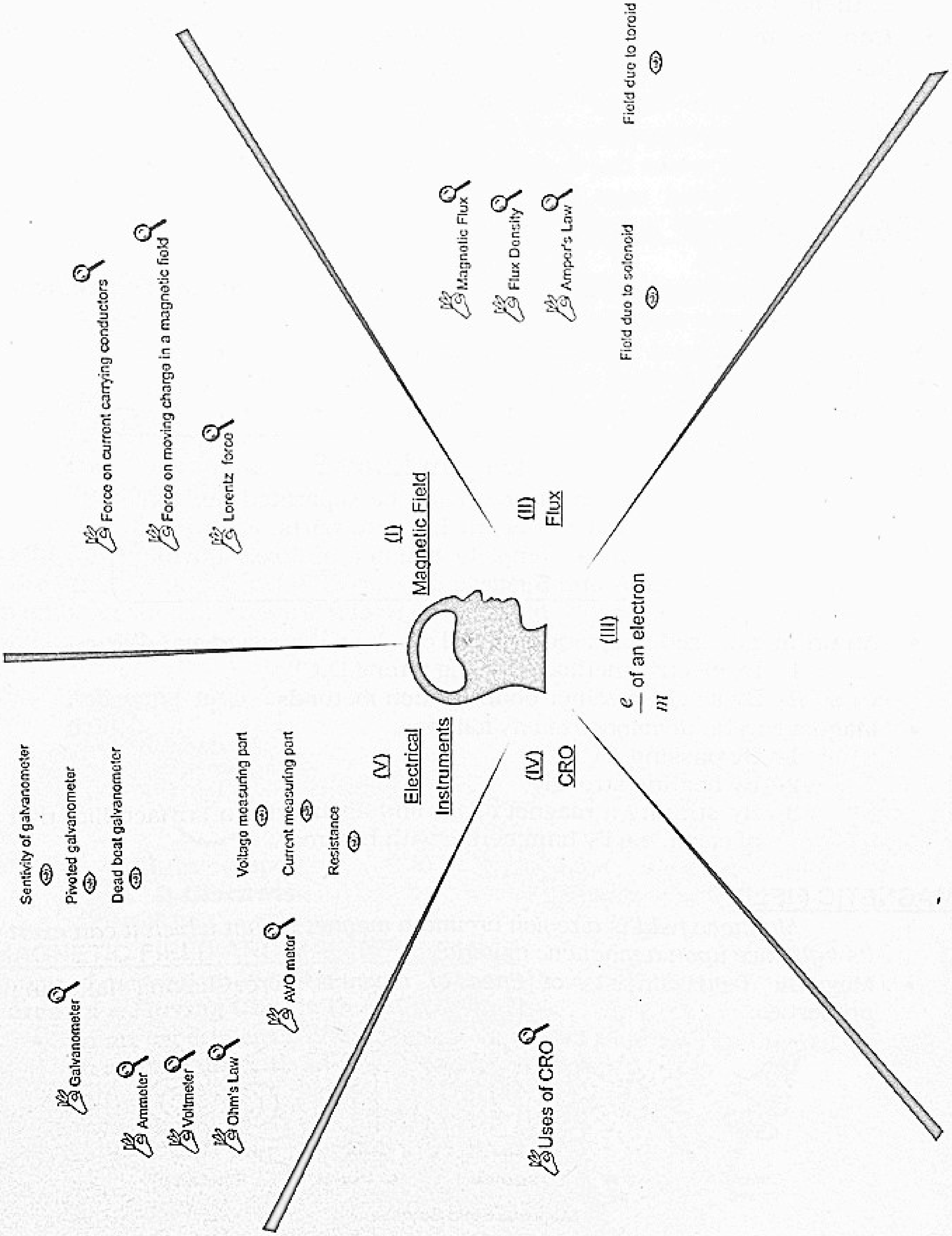
I=1A

T=3600s

Q=

Chapter 14

ELECTROMAGNETISM



Chapter 14 Electromagnetism

Introduction

- Study of magnetic properties is called *magnetism.*
- Study of magnetic properties associated with electricity and laws relating to them is called *electromagnetism.*
- Iron ore magnetite (Fe_3O_4) was discovered as **early as 600 B.C** from Magnesia, a region in Asia Minor, situated **in modern** Turkey.
- Ore magnet was named "***LODESTONE***" meaning leading stone, having directional property.
- *Magnetic field arises due to moving charges.*

CHARACTERISTICS OF A MAGNET

- It has two poles.
- North Pole of magnet coincides with the South Pole of earth's magnet & vice versa.
- Magnetism at poles is greater than at middle.
- Like poles attract while un-like poles repel each other.
- Freely suspended magnet sets itself along N-S direction.

Do you know?

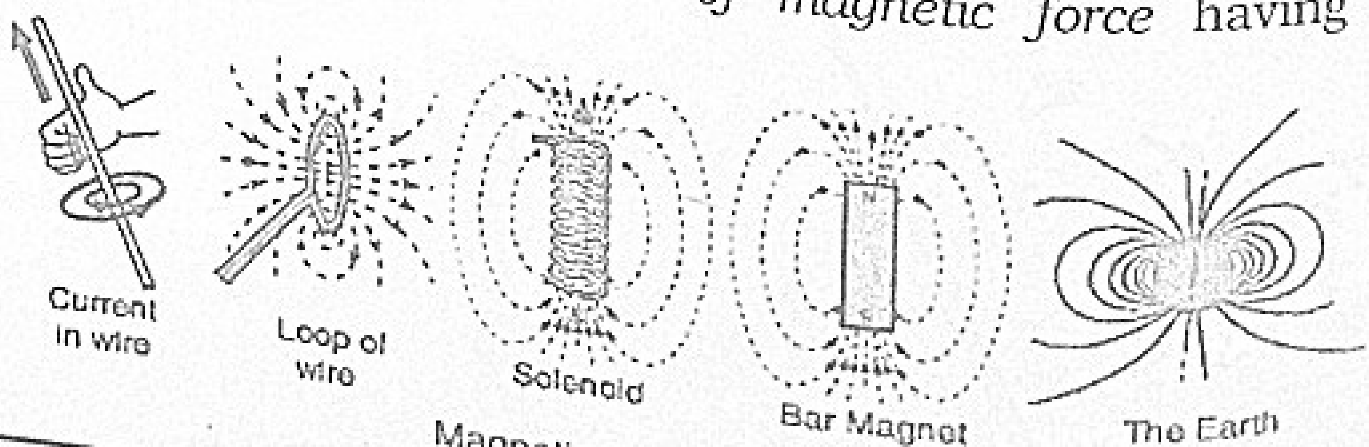
Poles of a magnet can't be separated i.e. if a large magnet is cut into two parts, each part will be a complete magnet in itself having both N and S poles.

- An un-magnetized magnetic material can be *magnetized* as follows:
  1- By electric method (passing strong D.C)
  2- By single touch or double touch methods.
- Magnet can be *demagnetized* as follows;
  1- By passing A.C
  2- By heating strongly
  3- By striking a magnet again and again with a surface like that of earth. e.g by hammering with hammer.

MAGNETIC FIELD

Magnetic field is a region around a magnet within which it can exert its influence upon a magnetic material.

- Magnetic field consists of *lines of magnetic force* having following properties:



Magnetic Field Sources

Chapter 14 Electromagnetism

1- Magnetic lines of force are curved followed by an isolated unit N-pole.
2- Two magnetic lines of force can't intersect each other.
3- Magnetic lines of force fill whole space around a magnet.
4- Magnetic lines of force emerge from N-pole and end on S-pole.
5- The no. of magnetic lines at a point gives strength of magnetic field.
6- Longitudinally they tend to shorten their length. It explains attraction between opposite poles.
7- Transversely they repel each other. It **explains the repulsion between** two like poles.

- Direction of *magnetic field is found by right hand rule for* ***positive charges*** *or conventional current.*

Magnetic Field Due to Current in a Long Straight Wire

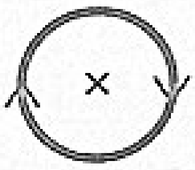
It is found that a magnetic field is set up in the region surrounding a current carrying wire.

- The lines of force are circular and their direction depends upon the direction of current.
- The magnetic field lasts only as long as the current is flowing through the wire.

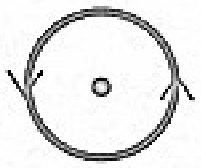
Right Hand Rule

If the wire is grasped in fist of right hand with the thumb pointing in the direction of the current, the fingers of the hand will circle the wire in the direction of the magnetic field

- Following figures should be kept in mind about direction of magnetic field.



I-(Into paper)
B-Clockwise



I-(Out of paper)
B- anti- clock wise

MAGNETIC FIELD AND MAGNETIC FORCE

Origin of magnetism is motion of charges, was found by ***Oersted.***

Force on a Moving Charge in a Magnetic Field

- In an experiment with bar magnet and field produced by charges flowing in a wire (current), following results are drawn;

⇒If $V \,||\, B$, then $F_m = 0$
⇒If $V \perp B$, then $F_m = max.$
⇒ $F_m \perp V$ and $F_m \perp B$
⇒ $F_m \propto q$
⇒ $F_m \propto V$
⇒ $F_m \propto B$

- Single equation containing all above said properties is;

  $\vec{F}_m = q(\vec{V} \times \vec{B})$

- Magnetic field can be given as;

  $B = F_m / qV\sin\theta$

  So *magnetic field strength* is defined as magnetic force acting on a unit charge, entering perpendicularly through a magnetic field with speed of 1 m/s.

- *If $F_m = 1N$, $q = 1C$, $V = 1m/s$, then $B = 1$ Tesla.* if $\theta = 90°$

  $1\ T = N/C\ m/s$

  So magnetic field is said to be IT, if 1N force acts on a charged particle carrying 1C charge and entering a magnetic at a speed of 1m/s perpendicularly.

Force on a Current Carrying Conductor in a Uniform Magnetic Field

- *Current carrying conductor experiences a force when placed in a uniform **magnetic field*** that is given by;

  $\vec{F}_m = I(\vec{L} \times \vec{B})$

  Where L is a vector having length equal to that of conductor and direction as that of current.

- *Drift speed of an electron* in a conductor is given as;

  $V_d = I / nAe$

- Magnetic field can be given as;

  $B = F_m / IL$

  So *magnetic field* is defined as magnetic force acting on a conductor of 1m carrying 1A current and placed ⊥ to magnetic field.

- If $F_m = 1N$, $I = 1A$, $L = 1m$ & $\theta = 90°$, then B= 1 Tesla

  $1T = N / A.m$

  So magnetic field is said to be IT if 1N force acts on a conductor of 1m carrying IA current and placed ⊥ to magnetic field.

- *Gauss is a small unit of B.*

  $1\ T = 10^{+4}\ G$

- Following figures should be kept in mind about direction of magnetic field.

CURRENT CARRYING COIL PLACED IN A UNIFORM MAGNETIC FIELD

Current carrying coil placed in a uniform magnetic field experiences a torque given by;

$\tau = NIAB\cos\propto$ or $NIAB\sin\theta$

Where N = No. of turns in coil
A = Face area of coil,
$\propto$ = Angle between plane of coil and B
θ = Angle between outword normal to the plane of coil and magnetic field

Note: Net force on coil is zero but net torque is not zero.

MAGNETIC FLUX AND MAGNETIC FLUX DENSITY

Magnetic flux is defined as a dot product of magnetic field and area.

$\phi_m = \vec{A}.\vec{B} = AB\cos\theta$

$= B\ A$ when $\theta = 0°$

We can rearrange above formula and get-

$B = \phi_m/A$

where B is *magnetic flux density or flux per unit area.*

- *Unit of magnetic flux is Weber (Wb).*

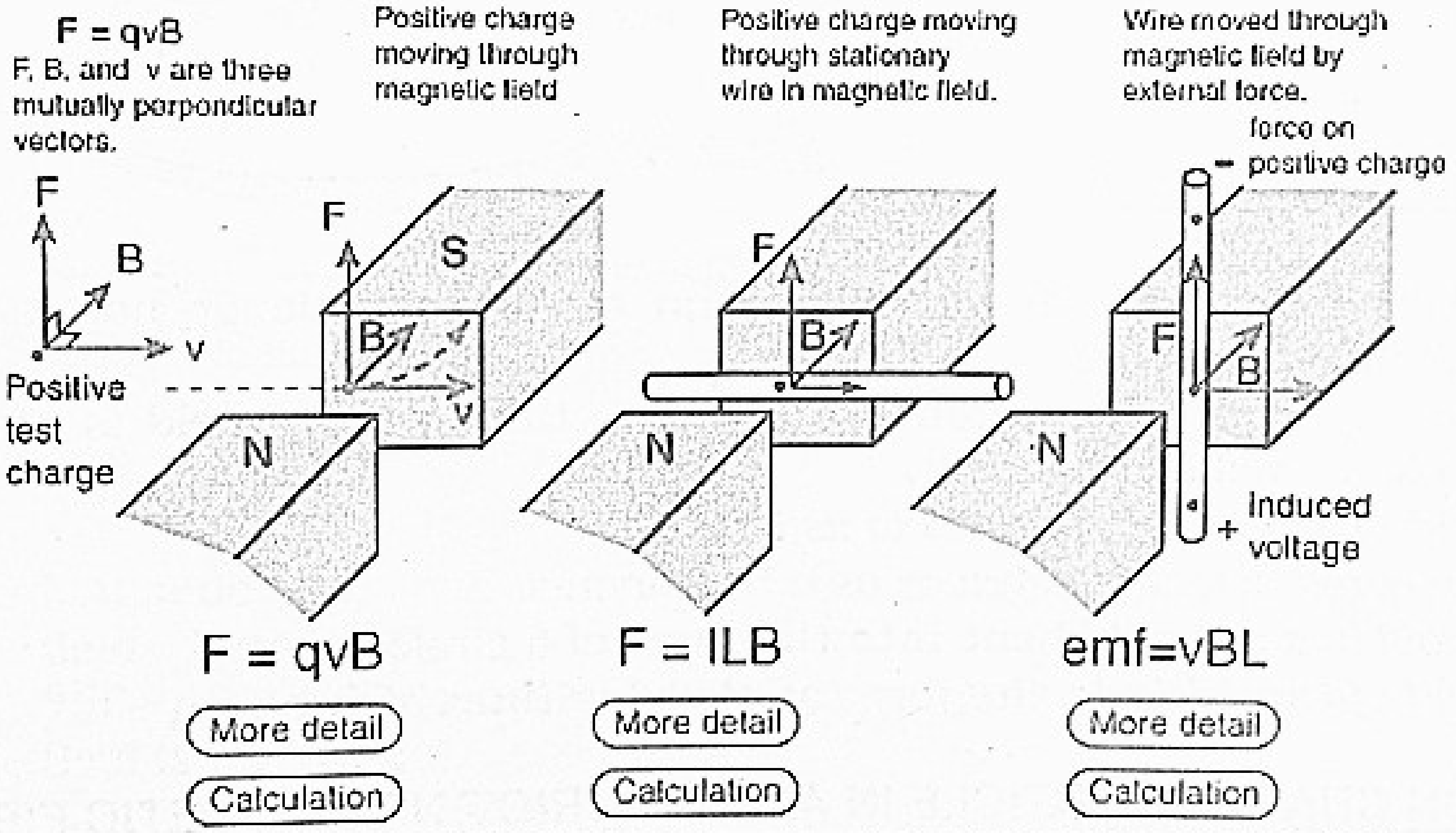
$\phi_m = 1\text{Wb}$ if $B = 1\text{ T}$ & $A = 1\text{m}^2$

$1\text{Wb} = 1\text{T. Im}^2$

$1\text{Wb} = 1\text{ NmA}^{-1}$

Magnetic Interactions with Moving Charge

This is an active graphic. Click on any part for further details.


F = qvB
F, B, and v are three mutually perpendicular vectors.
Positive charge moving through magnetic field
Positive charge moving through stationary wire in magnetic field.
Wire moved through magnetic field by external force.
force on positive charge
F
B
v
Positive test charge
S
N
F
B
N
F
B
N
Induced voltage
+
F = qvB
F = ILB
emf=vBL
More detail
Calculation
More detail
Calculation
More detail
Calculation

Applications	Applications	Applications
Cyclotron	Electric motor	Generator
Mass spectrometer	Galvanometer	Microphone
Tokamak	Voltmeter, ammeter	Stereo cartridge
Magnetohydrodynamics	Loudspeaker	Hall effect

- **Ampere's law is used to find the magnetic field strength**

AMPERE'S LAW

Definition

The sum of the quantities $\vec{B}.\vec{\Delta L}$ for all path elements into which the complete loop has been divided equals μ_o time the current enclosed by the loop.

$$\sum_{r=1}^{n}(\overrightarrow{B}\cdot\overrightarrow{\Delta \ell})_r = \mu_o I$$

I = current enclosed by closed path

Where $\mu_o = 4\pi \times 10^{-7}$ Wb / A.m

Applications

Field due to solenoid

$B = \mu_o n I$

where n = No. of turns per unit length = N/L

Field due to toroid

$B = \mu_o n I$

where $n = N/2\pi r$

Point to Ponder

Is it possible that we keep on increasing the number of turns of coil but the magnetic field strength remains constant? Yes. Why?

SOLENOID AND TOROID

- *Solenoid* is a cylindrical coil wound on a magnetic or non-magnetic material called core.
- When current flows through a solenoid, the magnetic field is produced inside as well as outside it.
- *Field of solenoid is parallel to its length.*
- *Iron cored solenoid behaves as a bar magnet.*
- *Toroid* is a solenoid **bent into the form of** a circle.
- *Field of* ***toroid is in the form of circular lines*** *of force.*

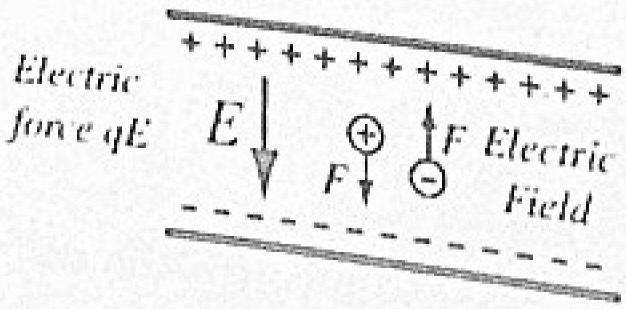
FORCE ON CHARGE PARTICLE IN AN ELECTRIC AND MAGNETIC FIELD

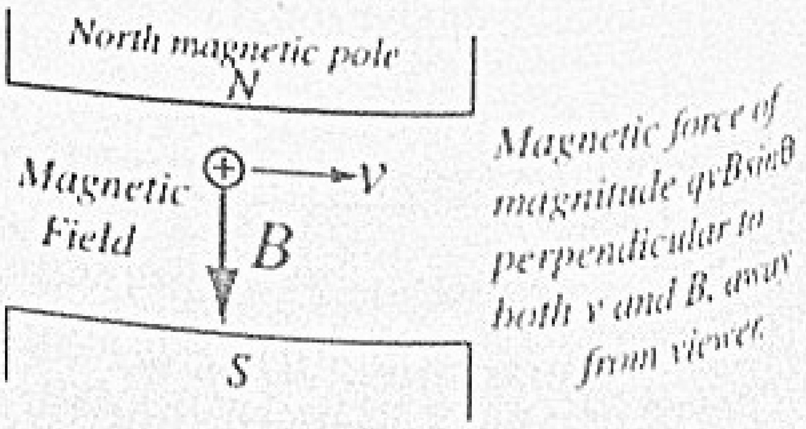
As,

$$\overrightarrow{F_e} = q\overrightarrow{E}, \text{ and } \overrightarrow{F_m} = q\overrightarrow{V} \times \overrightarrow{B}$$

$$\overrightarrow{F} = \overrightarrow{F_e} + \overrightarrow{F_m}$$

$$\overrightarrow{F} = q\overrightarrow{E} + q(\overrightarrow{V} \times \overrightarrow{B})$$




North magnetic pole
N
Magnetic Field
V
B
S
Magnetic force of magnitude qvBsinθ perpendicular to both v and B, away from viewer.

Where $\vec{F}$ *is called* ***Lorentz force***. If charge is of mass in uniform electric field then

$$\vec{a} = \vec{F}/m$$

Electric force does work

Magnetic force does no work.

MOTION OF A CHARGED PARTICLE IN A MAGNETIC FIELD

- *When a narrow beam of electron moving with a constant speed V be projected at right angles to a known uniform magnetic field* ***B*** *directed into plane of paper. The electrons experience of force at right angle to their direction and their will start moving in a circular path as sown in figure*

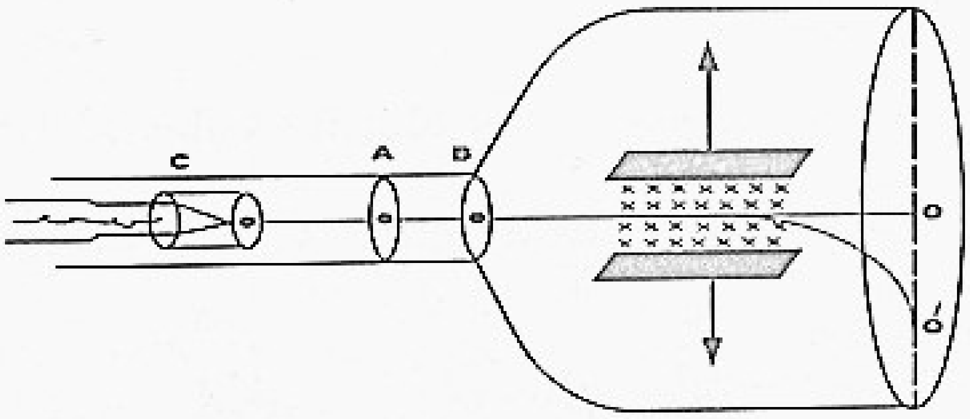
$$F_C = F_m$$

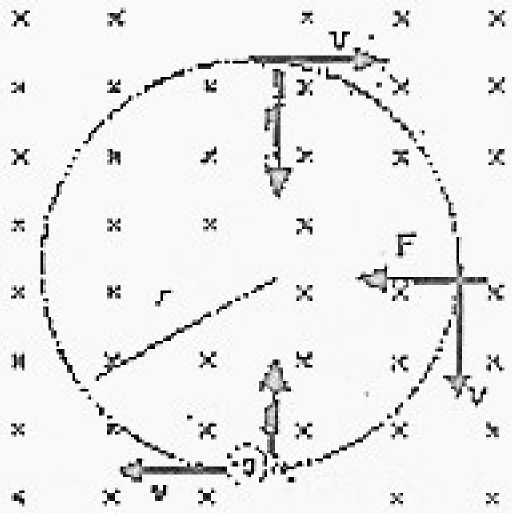
$$\frac{mV^2}{R} = qVB$$

$$mV = qBR$$

$$R = mv/qB = p/qB$$

p is the momentum of particle





- Magnetic force can do no work on charged particle entering magnetic field because $F_m \perp V$ **(always).**
- *Time period* of charged particle subject to circular motion in a magnetic field is given as;

$$T = \text{circumference} / \text{velocity}$$
$$= 2\pi R/V = 2\pi\, mV/qBV$$
$$= 2\pi m/qB$$

- *Frequency* of charged particle circulating in a magnetic field is given as;

$$f = 1/T$$
$$f = qB/2\pi m$$

It is known as **cyclotron frequency.**

- *If a particle has both component of velocity* $V\perp$ *and* $V||$ *and is allowed to enter a magnetic field of B, it* ***adopts helical motion.***

- *If force is at 90°, then it only changes* ***direction not the speed.***

e/m RATIO

- e/m of a charged particle can be given as;

  $e/m = V/BR$

  Where *R is determined by* ***Thomson's apparatus*** while velocity is determined by following two methods:

Potential difference method:

$v = \sqrt{2V_o e/m}$

so that $e/m = 2V_o/B^2 R^2$

Velocity selector method:

$v = E/B$

so that $e/m = E/B^2 R$

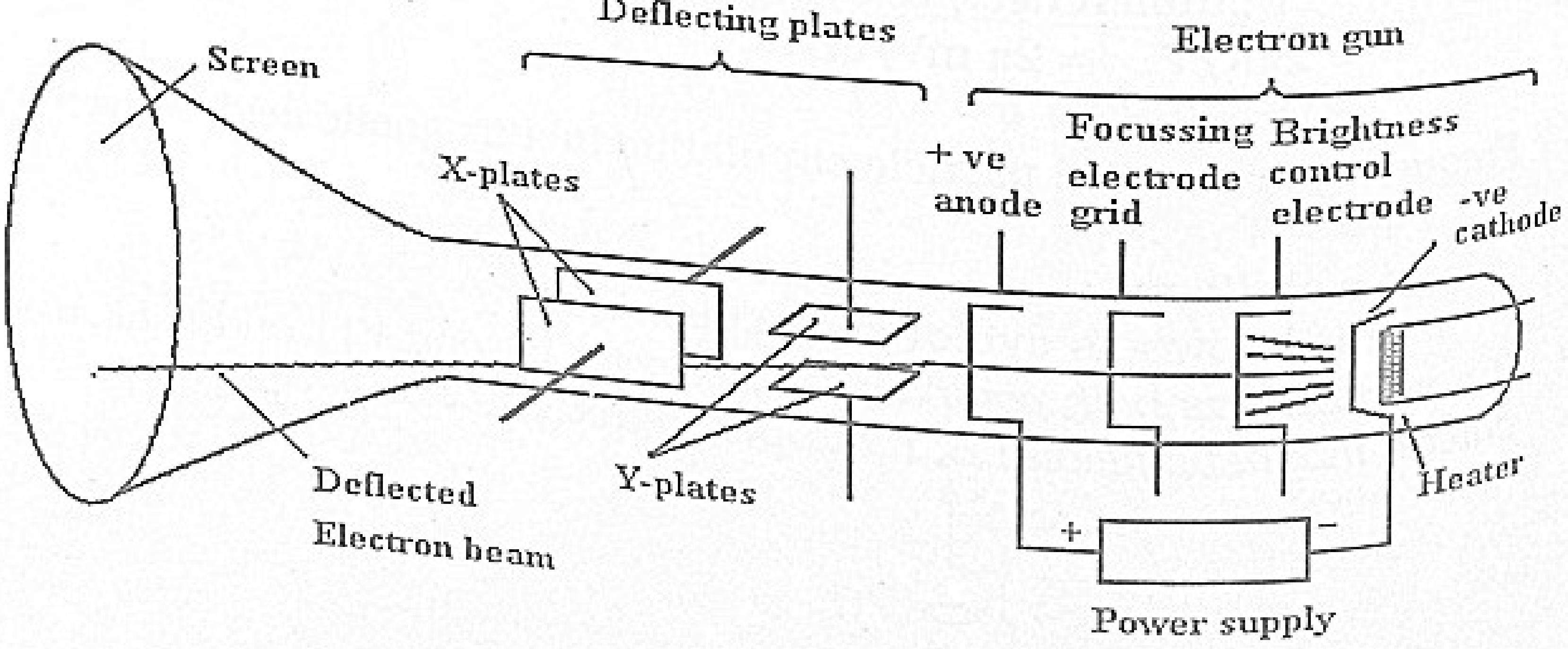
Point to ponder
The e/m of a proton is greater or less than an electron?

The value of e/m is equal to 1.7588 x 10^{11} C / kg

CATHODE RAY OSCILLOSCOPE (CRO)

- It is a high-speed graph-plotting device same as **picture tube of T.V** set or monitor of a computer.
- *Electron beams are produced* and they are deflected by voltage or current pulses.
- Fluorescent screen make it visible.
- A *grid* is used to control the number of electrons.
- The grid is at a negative potential with respect to cathode.
- *Electrons are accelerated by anode.*
- CRO is used for displaying the waveform of given **voltage** or current.
- Once the waveform is displayed, we can measure the voltage, its frequency and phase.

Cathode ray oscilloscope



TORQUE

- A current carrying coil placed in magnetic field, will be rotated, in magnetic field, producing torque.

$$\tau = BINA \cos \alpha$$

where α is the angle made by the **plane** with the **magnetic field**.
N is the **number of turns** of the coil
A is the **area of** the **coil.**

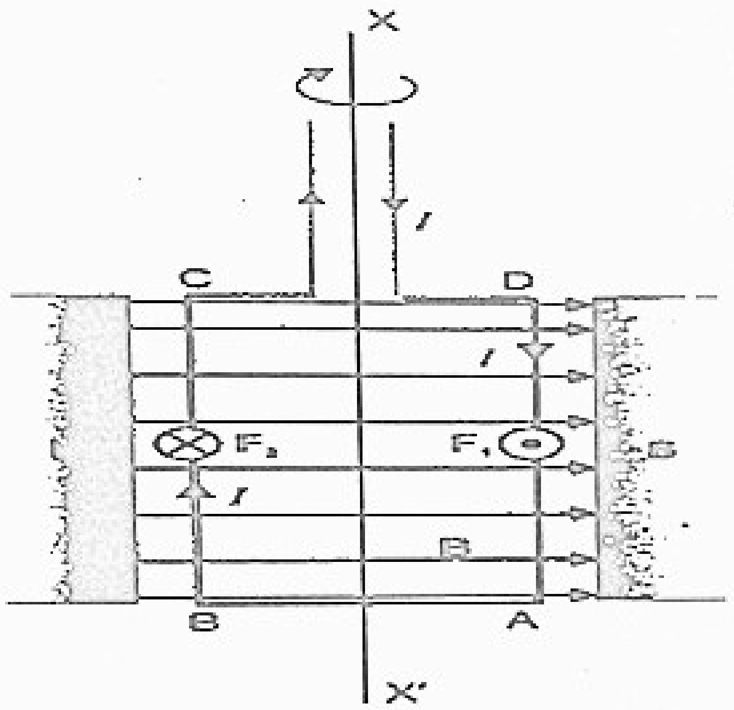
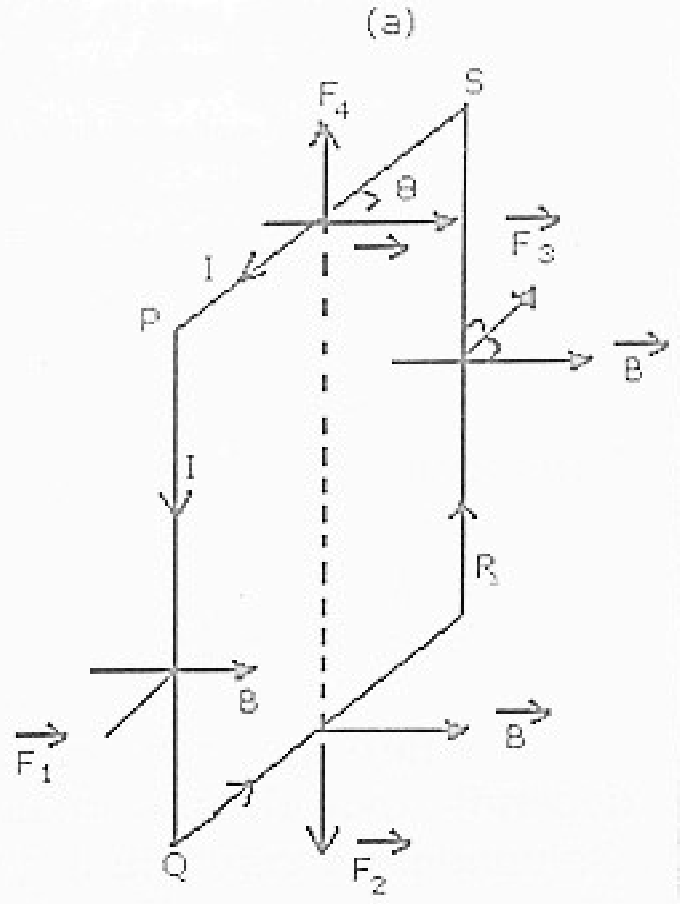
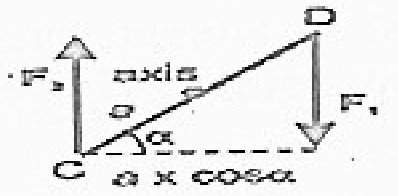


Fig 14.15 (a)





(Top view of coil)
Fig 14.15 (b)

ELECTRICAL MEASURING INSTRUMENTS

Electrical measuring instrument are those devices, which convert ***electrical energy into mechanical energy.***

Examples

1- Galvanometer
2- Voltmeter
3- Ammeter
4- AVO meter

Do you know?

All the electrical measuring instruments can only read current because current is the characteristic that can be measured as it can show physical effects. So all measuring instrument show different scales only but they are measuring current e.g. a voltmeter can measure voltage but actually it measures current and display it on the scale of volts.

Chapter 14

Electromagnetism

GALVANOMETER (G.M)

Galvanometer is used for the detection both A.C and D.C currents & voltages.

- *Principle of G.M*

  "Current carrying coil experiences electric torque $\tau = NAIB\cos\alpha$, when placed in a magnetic field."

- Galvanometer is *a parent instrument,* which can be converted in to voltmeters and ammeters etc.

- ***Types***

  1- Moving coil G.M (MCGM)
  2- Moving magneti G.M (MMGM)

- ***Major parts of moving coil G.M***

  1- pole piece made concave
  2- suspension wire
  3- lamp-scale arrangement
  4- coil
  5- hair springs.

- When coil of G.M stops after deflection, then-

  Deflecting torque = Restoring torque

  $I\,N\,A\,B\cos\alpha = C\theta$

  Here $\alpha = 0$,

  $$I = C\theta/BAN = K\theta$$

  Where *c represents couple per unit twist or torsion constant* that depends upon the nature and **geometry of suspension strip.**

- *Galvanometer constant* is given as;

  $$K = C/BAN$$

- A G.M can be made sensitive by making $K = C/BAN$ small.

  1- C is made small by increasing the length and decreasing the diameter of suspension wire
  2- A, B, N are made large

  Note: *Best suggestion is to made* ***B as strong as possible***

Do you know?

The needle of the galvanometer should stop quickly at the mean position, thus should suffer lesser oscillations. So the galvanometers are designed such that these oscillations can be minimized so they are critically damped. Such type of galvanometer is called dead head galvanometer.

- ***Modifications in Weston-type Galvanometer***

  1- Suspension wire is replaced by shaft with pivot.
  2- Lamp-scale arrangement is replaced by light aluminum needle and graduated scale.

Ammeter

Galvanometer is used for the measurement of current when converted into ammeter.

- *G.M can be converted into A.M by connecting a shunt (low resistance) in parallel to its coil.*

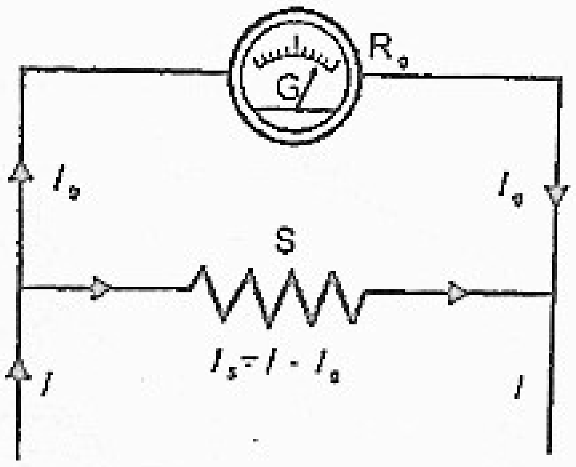
  Value of shunt is given as;

  $R_s = I_g R_g / I - I_g$

  where I is called range.
- *To increase the range of A.M, shunt should be made more small*
- Range of A.M is given by;

  $I = Ig\ (I + R_g / R_s)$

  It shows $I \propto 1/R_s$ and to so make A.M more sensitive, its R_s is reduced
- A.M is *always* ***connected in series.***
- An ammeter must have a very low resistancec so that it does not disturb the circuit resistance.



Voltmeter

Voltmeter is a high resistance G.M.

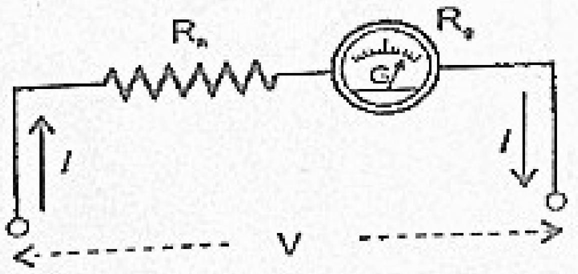
- *To convert G.M into V.M, a high resistance R_h is connected in series with its coil.*
- High resistance (multiplier), which converts G.M to V.M is given as;

  $R_h = V/I_g - R_g$

  where *V is called* ***range of voltmeter***
- Range of voltmeter is given as;

  $V = I_g (R_g + R_h)$

  It shows that $V \propto R_h$ so *making resistance R_h higher can make a V.M* ***more sensitive***
- Voltmeter is *always* ***connected in parallel.***
- Reading of V.M is not accurate as it draws some current for its working. Hence it measures **less voltage than actual.**
- For accurate measurement of voltage, **potentiometer is used.**



OHM METER

- Rapidly measures resistance.
- An adjustable resistance along with cell is used internally in ohmmeter. This adjustable resistance is called *current limiting resistance*

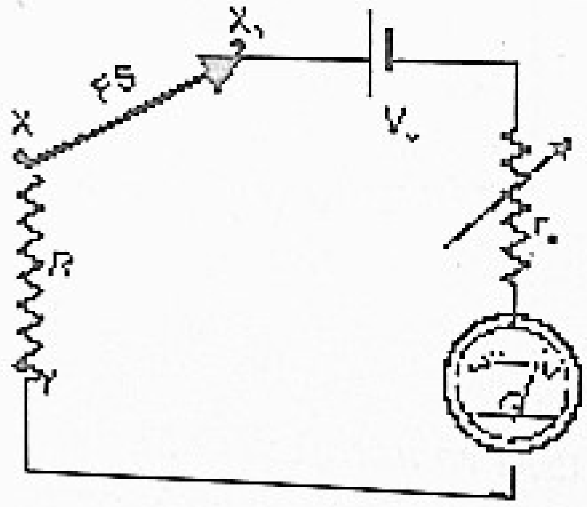
AVO METER

AVO meter is an electrical measuring instrument used for the measurement of current, voltage and resistance

A for Amp
V for Volt
O for Ohm

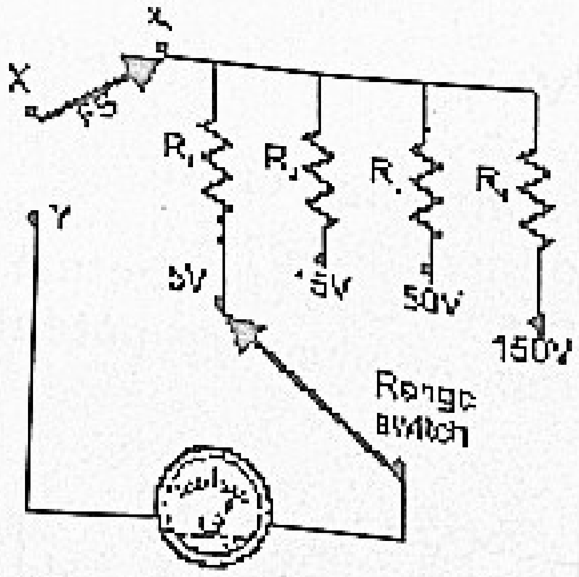
AVO METER AS OHMMETER

- Circuit of AVO meter measurement of resistance is given below:



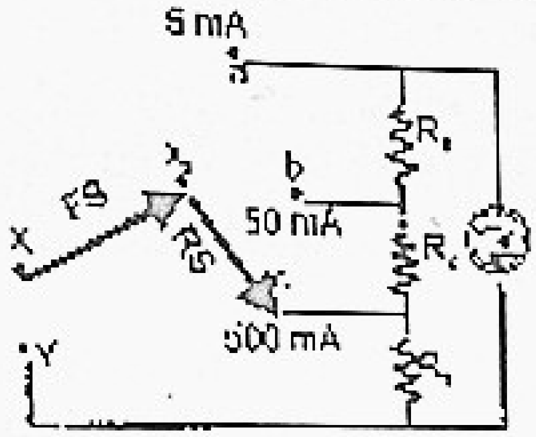
AVO METER AS VOLTMETER

- Circuit of AVO meter for measurement of **voltage is** given below;
- Set of resistance connected in series to coil of **G.M is called** ***multiplier***, as shown below:



AVO METER AS AMMETER

- Set of shunts connected in parallel is called *universal shunt or Aryton*



- *No. of scales on AVO meter are three.*
  1- Ohm scale
  2- Current scale both for A.C & D.C
  3- Voltage scale both for A.C & D.C

DIGITAL MULTIMETER (DMM)

*It is AVO meter but have digital **displaying**.*

- It gives decimal counting, polarity and unit for V, A or Ω.
- It is free from human errors of **polarity selection.**

PRACTICE EXERCISE

30 Time Yourself

(1) The powers two electric bulbs are 100W and 200W. Both of them are joined with 220V mains. The ration of resistance of their filaments will be

(a)1:1
(b)1:2
(c)2:1
(d)4:1

(2) A current carrying conductor is placed in a uniform magnetic field parallel to it. The magnetic force experienced by the conductor is________

(a)$F=1/B$
(b)$F=1/B\sin\theta$
(c)$F=0$
(d)$F=1/B\cos\theta$

(3) What is the value of the current in a wire of 10cm long at the right angle to a uniform magnetic field of 0.5 Weber/m², when the force acting on the wire is 5N?

(a)1A
(b)10A
(c)100A
(d)1000A

$F = Bil$
$= 0.5 \times A \times 10 \times 10^{-2}$
$= 5 \times 10^{-2} A$

(4) When a particle of charge q and mass m enters into a uniform magnetic field B moving with a velocity v perpendicular to the direction for the field, it describes a circular path of radius________

(a)$R=qB/mV$
(b)$R=mV/qB$ ✓
(c)$R=qmV/B$
(d)$R=qmB/V$

$q/m = \frac{v}{Br}$

(5) When a particle of charge q and mass m enters the uniform magnetic field B moving with velocity v perpendicular to the direction of the field, the time required by a charged particle to make a complete revolution in a magnetic field is given by________

(a)$T=2\pi q/Bm$
(b)$T=2\pi m/qB$ ✓
(c)$T=2\pi B/qm$
(d)$T=qB/2\pi m$

(6) Two parallel wires carrying currents in the opposite directions________

(a)repel each other ✓
(b)attract each other
(c)have no effect upon each other
(d)they cancel out their individual magnetic fields

(7) A magnetic compass will be deflected if it is kept near a________

(a)charge in motion
(b)charge at rest
(c)both
(d)none

(8) A magnetic field________

(a) always exerts a force on a charged particle
(b) never exerts a force on a charged particle
(c) exerts a force if the charged particle is moving in the direction of the magnetic field lines
(d) exerts a force if the charged particle is moving perpendicular to the magnetic field lines

(9) A moving coil galvanometer of resistance 100Ω gives half scale deflection for a current of 20mA. What will be the potential difference across it?

(a) 4 volt
(b) 5 volt
(c) 2 volt
(d) 0.4 volt

V = IR = 20x100x10
= 2000

(10) Which one of the following material is most suitable for making core of an electromagnet?

(a)air
(b)steel
(c)Cu-Ni alloy
(d)soft iron ✓

(11) The magnetic force experienced by a charge particle moving in a magnetic field will be minimum when it moves ______

(a)perpendicular to the field
(b)parallel to the field
(c)inclined at some angle to the field
(d)inclined at an angle of 45°

(12) The relationship between Tesla and smaller unit Gauss of magnetic induction is given by ______

(a) 1T = 10^3 G
(b) 1T = 10^{-4} G
(c) 1T = 10^{-2} G
(d) 1T = 10^4 G ✓

(13) If the plane of the rectangular coil is parallel to the magnetic field (i.e. radial magnetic field), the torque on the coil is ______

(a) τ = NIAB cosα
(b) τ = NIAB sinα
(c) τ = NIAB tanα
(d) τ = NIAB ✓

(14) SI unit of flux density is ______

B = F/IL

(a)$NA^{-1}m^{-1}$
(b)NAm^{-1}
(c)NmA^{-1}
(d)NmA^{-2}

(15) Magnetic flux and flux density are related by ______

(a)magnetic flux = flux density / area
(b)magnetic flux = flux density x area ✓
(c)flux density = magnetic flux area
(d)flux density = magnetic flux × area

(16) The standard vector symbol for flux density is ______

(a)M
(b)L
(c)H
(d)B ✓

(17) The charged particle enters the uniform magnetic field in such a way that its initial velocity is not perpendicular to the field, the orbit will be ______

(a)a circle
(b)a spiral
(c)an ellipse
(d)a helix ✓

(18) An electron enters a region where the electric field E is perpendicular to the magnetic field B. It will suffer no deflection if ______

(a)E = BeV
(b)B = eE/V
(c)E= BV
(d)E = BeV/2

(19) Value of permeability of free space in SI units is ______

(a)4πx10^{-9} $WbA^{-1}m^{-1}$
(b)4πx10^{-7} $WbA^{-1}m^{-1}$
(c)4πx10^{-10} $WbA^{-1}m^{-1}$
(d)4πx10^{-8} $WbA^{-1}m^{-1}$

(20) The magnetic field strength of a solenoid is

(a) B = μ_oNI
(b) B = μ_oN/I
(c) B = μ_onI
(d) both (b) and (c)

(21) An instrument, which can measure potential without drawing any current, is ________
(a) voltmeter
(b) galvanometer
(c) cathode ray oscilloscope (CRO)
(d) ammeter

(22) If the current passing through the a spring then the spring will
[✓ (a) compress] (b) expand
(c) remain same (d) none of these

(23) When the coil of the galvanometer is in equilibrium, then the deflecting couple is ________
(a)zero
[✓ (b)equal to the restoring couple]
(c)greater than the restoring couple
(d)smaller than the restoring couple

(24) The sensitivity of a galvanometer is given by
(a) C/BAN (b) CAN/B
(c) BAN/C (d) ABC/C

(25) Which one of the following is not an electromechanical instrument?
(a)galvanometer (b)voltmeter
(c)ammeter (d)AC transformer

(26) When charge particle enter into a magnetic field then K.E
(a)remain same (b)increases
(c)decreases (d)none of these

(27) In a multi range ammeter, as the range increases, ________
[✓ (a)shunt value decreases] (b)shunt value increases
(c)shunt value remains the same (d)none of the above

(28) The magnitude of force experienced by a stationary charged particle in a uniform magnetic field is
(a) maximum
(b)minimum
(c)zero
(d)remain same as experienced by moving charged particle

(29) The value of $\mu_0/4\pi$
(a) 10^{-7} $TA^{-1}m^{-1}$ (b) 10^{4} TA^{-1}
(c) 10^{-3} $TA^{-1}m^{-1}$ (d) 10^{-7} $TA^{-1}m$

(30) An ammeter measures the total current flowing through a circuit, when it is connected________
[✓ (a)in series with the circuit]
(b)in parallel with the circuit
(c)in series with any of the parallel resistances in the circuit
(d)in parallel with any of the series resistances in the circuit

(31) Coil of a galvanometer is suspended in a radial magnetic field so that the deflecting torque on the coil is always________
(a)BINA cosα (b)BINA sinα
(c)BINA tanα (d)BINA

(32) A galvanometer basically is an instrument used to ____________
(a)detect current in a circuit
(b)measure current flowing through a circuit
(c)measure voltage across a circuit
(d)measure potential difference between two points in a circuit

(33) The effective way to increase the sensitivity of a moving coil galvanometer is to ____________
(a)use a very long and fine suspension
(b)use a coil of very large area
(c)use a coil with very large number of turns
(d)use a very strong magnetic field

(34) A wheat stone bridge is said to be balanced when____________
(a)maximum current flows through the galvanometer branch
(b)minimum current flows through the galvanometer branch
(c)potential difference across galvanometer branch is maximum
(d)potential difference across galvanometer branch is zero

(35) When an electron moving with a uniform speed in a vacuum enters a magnetic field in a direction perpendicular to the field, the subsequent path of the electron is ____________
(a) a straight line parallel to the field
(b) a parabola in a plane perpendicular to the field
(c) a circle in a plane perpendicular to the field
(d) a straight line along its initial direction

(36) A particle of mass m charge q and speed V, enters a uniform magnetic field of flux density B. The path of the particle in the field is a circle of radius r. The radius r of the circle is ____________
(a) independent mass m
(b) directly proportional to m
(c) directly proportional to q
(d)directly proportional to B

(37) Galvanometer is a very sensitive device with____________
(a) very low damping
(b) very high damping
(c) no damping at all
(d) radial field disintegration

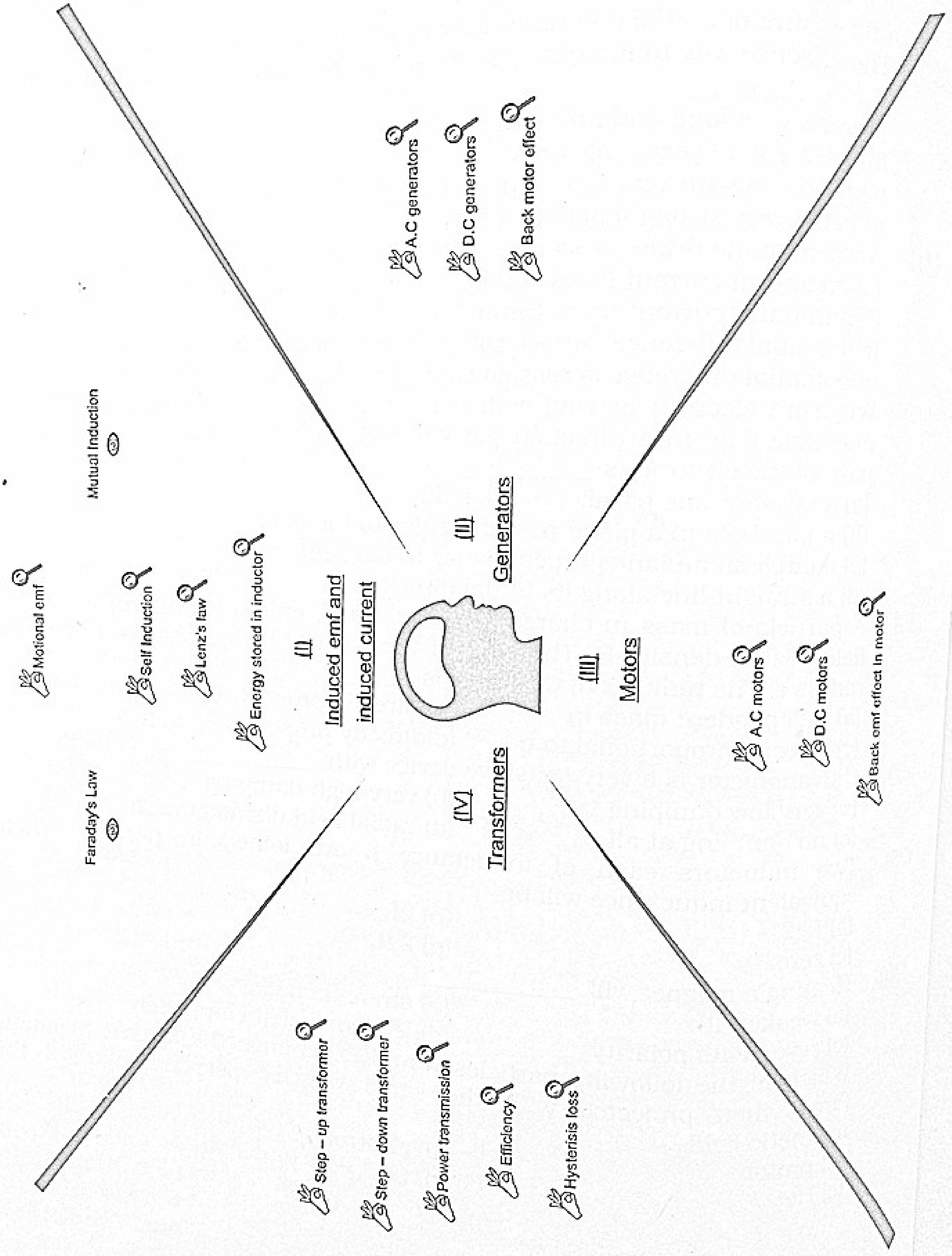
(38) Two inductors each of inductance L are joined in parallel. Their equivalent inductance will be
(a) L/2
(b) 2L
(c) zero
(d) 2/L

(39) Heating a magnet will ____________
(a) weaken it
(b) strengthen it
(c) reverse its polarity
(d)demagnetize it completely

(40) Which of the following particles would experience the largest magnetic force when projected with the same velocity perpendicular to the magnetic field
(a) proton
(b) electron ✗
(c) He^+
(d) Li^+ ✓

Chapter 15

ELECTROMAGNETIC INDUCTION



TOP Study

- ***Orested*** *discovered magnetic field* due to current carrying coil.
- ***Faraday*** *discovered electromagnetic induction* (production of induced emf and induced current)
- According to Faraday, *cause of* ***induced emf*** *and* ***induced current*** *is a* ***change of magnetic flux linked*** *with the coil* i.e. relative motion of loop and magnet.
- The induced current depends upon the speed with which the conductor moves and upon the resistance of the loop.
- The induced current can be increased by-
  - ✓ Using a stronger magnetic field
  - ✓ Moving the loop faster
  - ✓ Replacing the loop by a coil of many turns

Point to Remembers

As magnetic flux is

$\Phi m = B.A\ Cos\theta$

So the change in flux can be caused as:-

- Change in magnetic field strength.
- Change in projected area.
- Possible change in the orientation of coil in field.

FARADAY'S LAW

First law

Induced emf lasts till the **flux remains changing.**

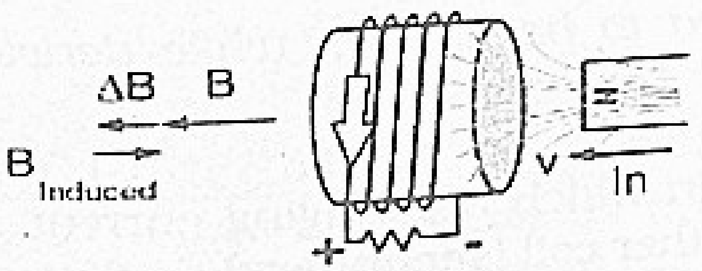
Second law

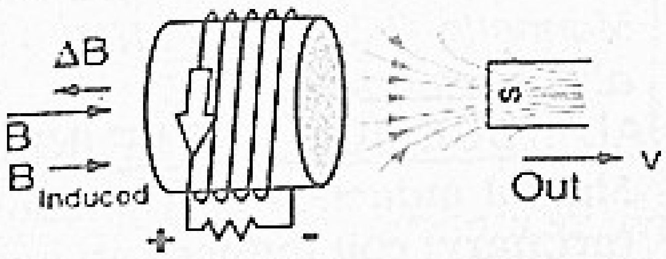
Induced emf is directly proportional to the rate of change of magnetic flux i.e.

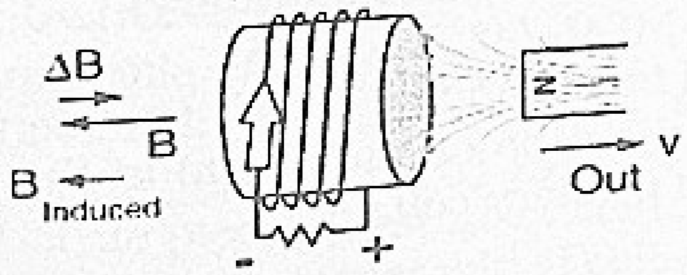
$$\epsilon = -N\frac{\Delta\varphi_m}{\Delta t}$$

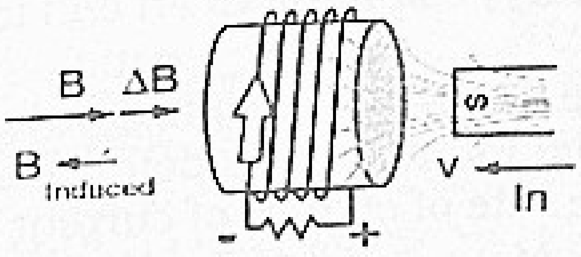
- Direction of induced e.m.f is given by ***Lenz's law***, which states:

  "e.m.f is induced in such a way that it opposes its own Cause of ***generation****"*
- Lenz's law is in accordance with the law of conservation of energy.









Chapter 15 Electromagnetic Induction

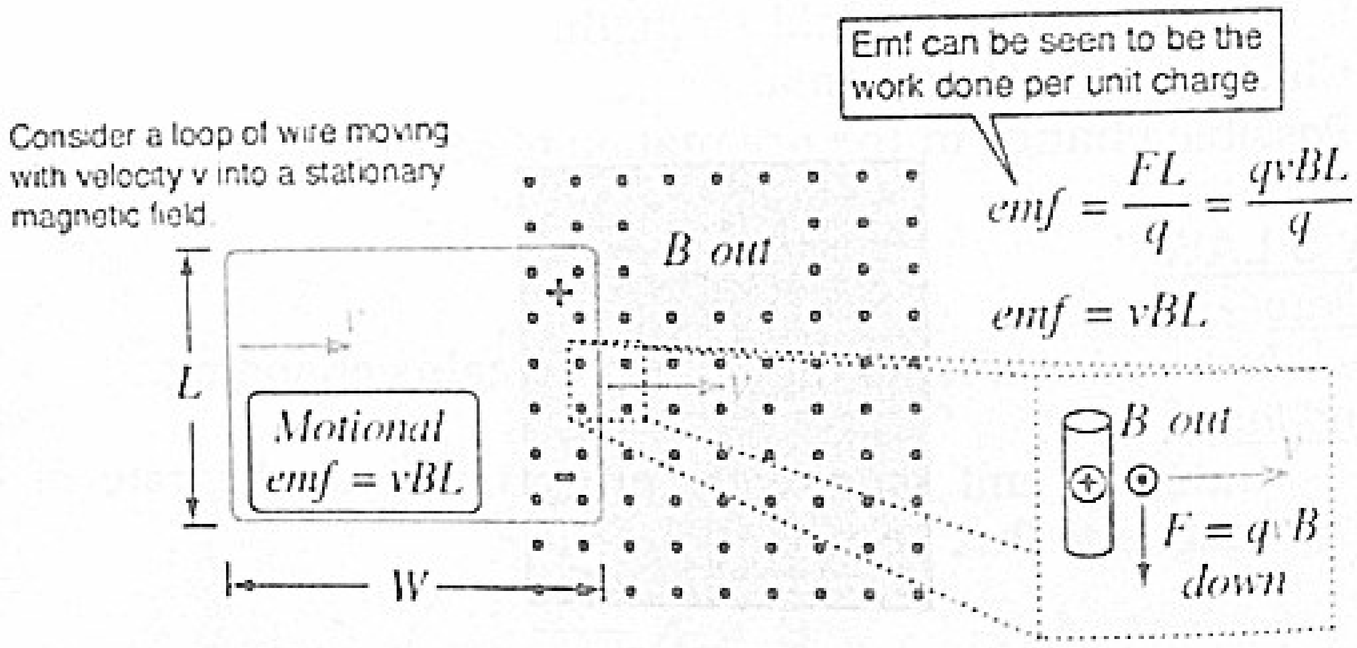
- The mechanism of generation of induced e.m.f is such that energy fed to change flux changes to magnetic force, which moves free electrons to cause current and **hence induced e.m.f.**
- Following ways can change magnetic flux (or in other words, can produce induced e.m.f): -
  - ✓ Motion of magnet.
  - ✓ Motion of coil.
  - ✓ Relative motion of coil and magnet.
  - ✓ Change of current.
- If there does not exist Lenz's law then perpetual motion machine of 1st kind was possible. Thus the process will be self-perpetuating.

MOTIONAL emf

The emf induced by the motion of a conductor across a magnetic field is called motional emf.

$$\mathcal{E}_{(\text{motional})} = -vBL$$

where v = speed of the conductor
L = length of the conductor


Emf can be seen to be the work done per unit charge
Consider a loop of wire moving with velocity v into a stationary magnetic field.
$emf = \frac{FL}{q} = \frac{qvBL}{q}$
$emf = vBL$
B out
+
−
L
W
v
Motional emf = vBL
B out
v
F = qvB down

- If there is some orientation of the coil to the magnetic field, then

$$\mathcal{E}_{(\text{motional})} = -vBL\sin\theta$$

where θ is the angle between v & B.

- *The unit of motional emf is volt.*
- *Magnetic field strength is considered to be uniform while deriving the above expression.*

MUTUAL INDUCTION & SELF INDUCTION

- *Mutual induction* is a phenomenon in which a changing current in one **(primary)** coil induces an emf in another coil **(secondary)**

$$\text{e.m.f}_{sec} = -M\ \Delta I_P/\Delta t$$

Where $M = N_s\Phi_s/I_p$ called mutual inductance.

- Mutual inductance is defined as the ratio of back e.m.f in the secondary to the rate of change of current in primary coil.

$$M = -\text{e.m.f}_{\ sec}/(\Delta I_p/\Delta t).$$

- ***Self-induction*** is a phenomenon of generation of induced e.m.f in a coil due to change of current in itself.

$$\text{e.m.f}_{self} = -L \quad \Delta I/\Delta t.$$

where L is called self inductance. Also **$N\Phi = LI$**

- Self-inductance is defined as the ratio of back e.m.f to rate of change of current in the same coil.

$$L = -\text{e.m.f}_{self} / (\Delta I/\Delta t)$$

- *SI unit of mutual or self inductance is Henry (H).*

(i) M = 1 H if $\text{e.m.f}_{sec} = 1V$ & $\Delta I_p/\Delta t = 1A/s$

Mutual inductance is said to be 1 H if a current change in primary at a rate of 1A/sec produce e.m.f of 1 volt in secondary.

(ii) L = 1 H if e.m.f = 1V & $\Delta I/\Delta t$ = 1 A/sec

Self-inductance is said to be 1H, if **current changing at the rate of 1 A/sec produces an e.m.f of 1V in the coil itself.**

ENERGY STORED IN AN INDUCTOR

Inductor is simply an insulated coil that ***offers very small resistance*** *to D.C current but offers* ***high resistance to A.C current.***

- In case of capacitor, energy is stored in electric field between the plates. Similarly, energy is stored in magnetic **field of the inductor.**
- Work done by the battery to move charges **against the induced emf** is

$$W = \tfrac{1}{2} LI^2$$

- This work is stored as potential energy in the inductor as

$$U_m = \tfrac{1}{2}LI^2$$

Also $L = \mu_o n^2 Al$

$U_m = \tfrac{1}{2}(\mu_o n^2 Al)I^2$

As $B = \mu_o nI$, then

Then $U_m = \tfrac{1}{2} B^2Al/\mu_o$

As Al = Volume

Then energy density is

$$U = U_m/Al = \tfrac{1}{2} B^2/\mu_o$$

or $U = \tfrac{1}{2} B^2/\mu_o$

- Inductor in an A.C circuit always resists the abrupt change in current.

Do you know?

The density of energy storage in an inductor is directly proportional to the square of the magnetic field strength provided all other factors remains constant.

A.C & D.C GENERATOR

Current generator is a device, which converts mechanical energy into ***electrical energy.***

- The *principle of generator* is that emf is induced across a coil moving in a magnetic field due change of **magnetic flux.**
- *Main parts of A.C generator*
  - ✓ Pole pieces (U-shape magnet) with concave poles.
  - ✓ Armature (assembly of coil on iron cylinder)
  - ✓ Slip ring (as connector)

✓ Carbon brush (external supply)

- emf is induced by the side of loop intersecting the **magnetic** field.
- Total emf for N number of loops is given as;

$$\mathcal{E} = N(2vB\ell \sin\theta)$$

also $$\mathcal{E} = N\omega AB \sin\omega t$$

$$\mathcal{E}_{max} = N\omega AB \quad \text{when } \theta = 90^\circ$$

then $$\mathcal{E} = \mathcal{E}_{max}\sin\omega t$$

If $$\omega = 2\pi f, \text{ then}$$

$$\mathcal{E} = \mathcal{E}_{max}\sin 2\pi ft$$

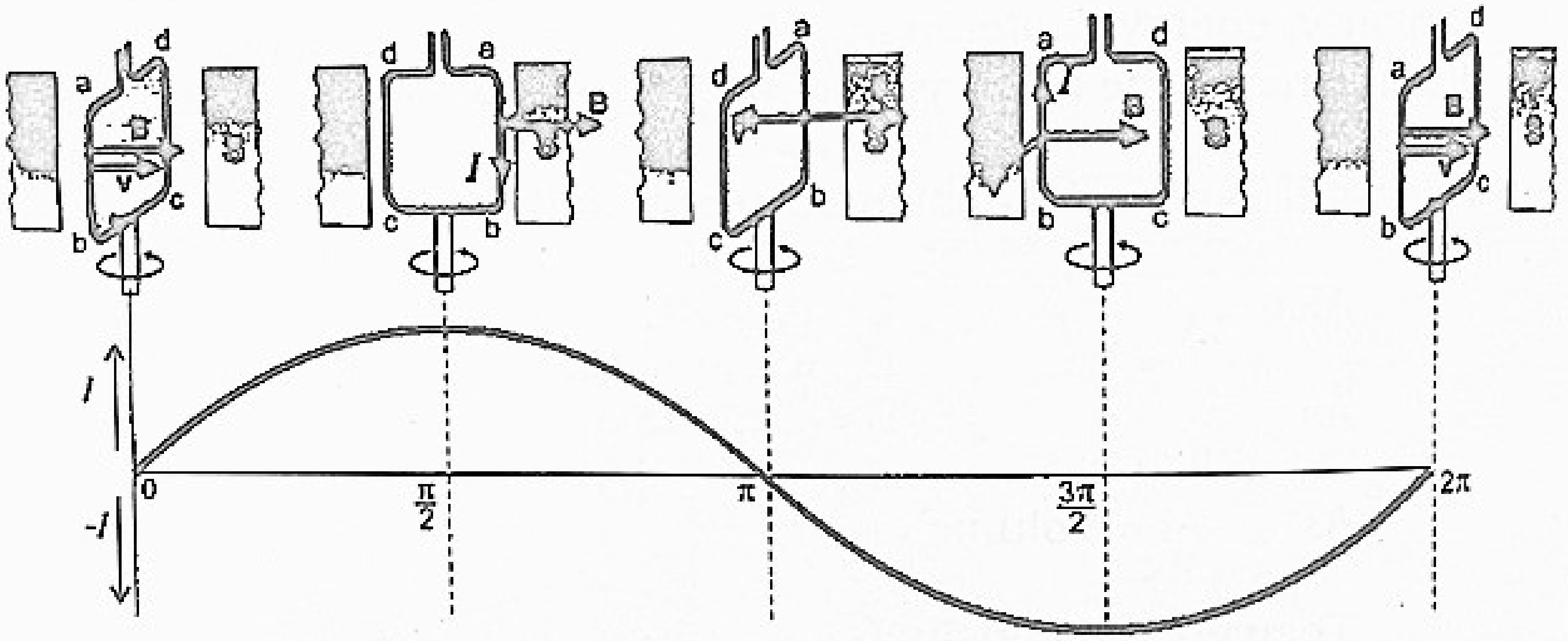
In terms of potential difference,

$$V = V_o \sin 2\pi ft$$

In terms of current,

$$I = I_o \sin 2\pi ft.$$

where f is the frequency with which the direction of current is changing.



- *In Pakistan f = 50Hz, it means 50 times in a second direction is changing.*
- *In D.C generator* ***split rings or commutators*** *are used in place of slip rings.*
- D.C generator produce one directional pulsating D.C, not pure D.C
- For pure D.C many coils are wound around cylindrical core

BACK MOTOR EFFECT IN GENERATOR

- The device in electric circuit that consumes electric energy (electricity) is known as ***load.***
- *The greater the load, the larger the current is supplied by the generator (indicated by sound of generator)*
- When the circuit is closed, a current is drawn through the coil. The magnetic field exerts force on the current carrying coil. This force produces a counter torque that opposes the rotational motion of the coil. This effect is called ***back motor effect of generators.***

- According to energy conservation law, the energy consumed by the load must come from the energy source used to **drive turbines.**
- The larger the current drawn by the load, the greater is the **counter torque produced.**

D.C MOTORS

A motor is a device converts ***electrical energy*** *into* ***mechanical energy.***

- A generator running backward is called motors.
- *Principle of motor* is that whenever a current carrying wire is placed in a magnetic field it experiences a force, which causes torque.

BACK E.M.F EFFECT IN MOTORS

- The induced emf in a motor opposes the emf **running the motor**. This induced emf is called *the* ***back emf of motor.***
- The magnitude of the back emf increases with the speed of motor.
- V & Є are in opposite polarity.

i.e. current flowing in motor is

$$I = (V - \epsilon)/R$$

or

$$V = \epsilon + IR$$

- As the motor speeds up, the back emf increases and the **current** becomes smaller and smaller. So current should be kept sufficient to provide torque.
- *If motor is overloaded, the back emf decreases and allow the motor to draw more current*
- *If motor is overloaded beyond its limits, the current could be so high that it may* ***burn*** *the motor.*

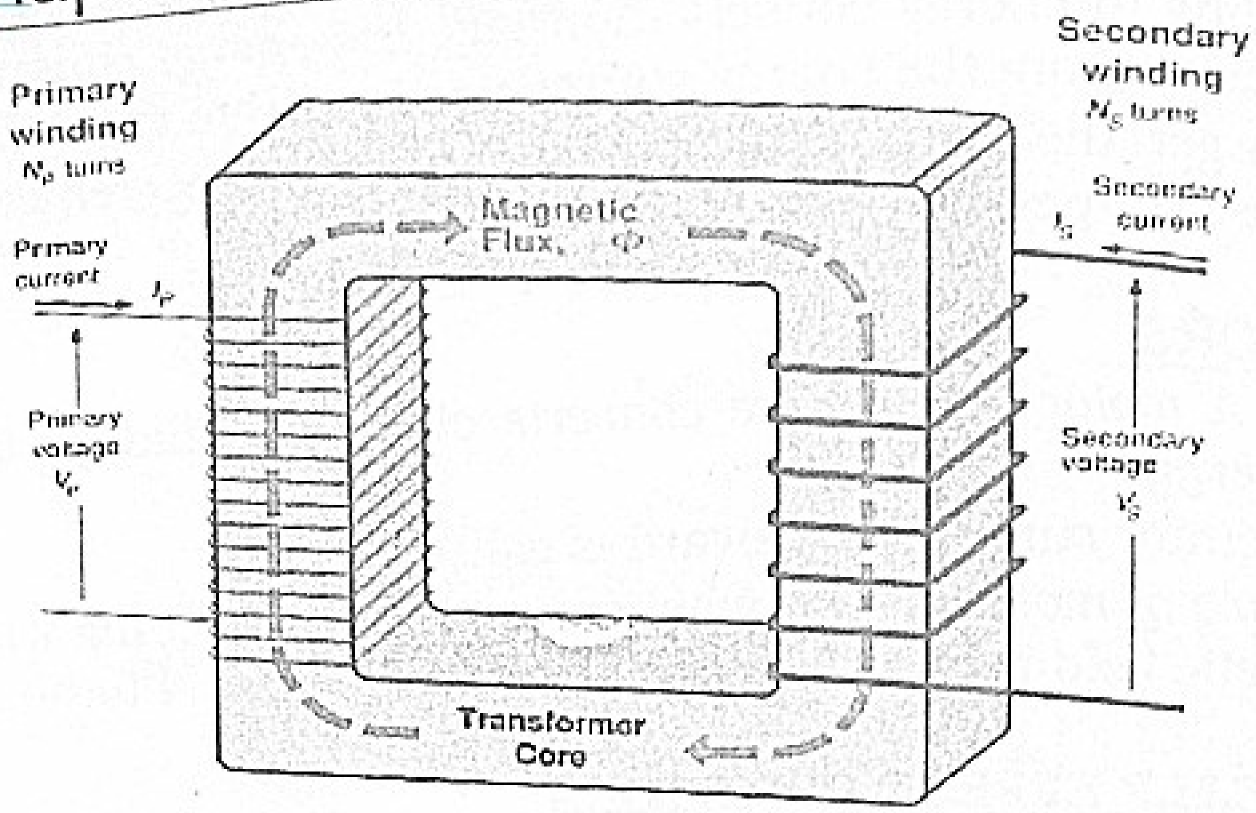
Do you know?

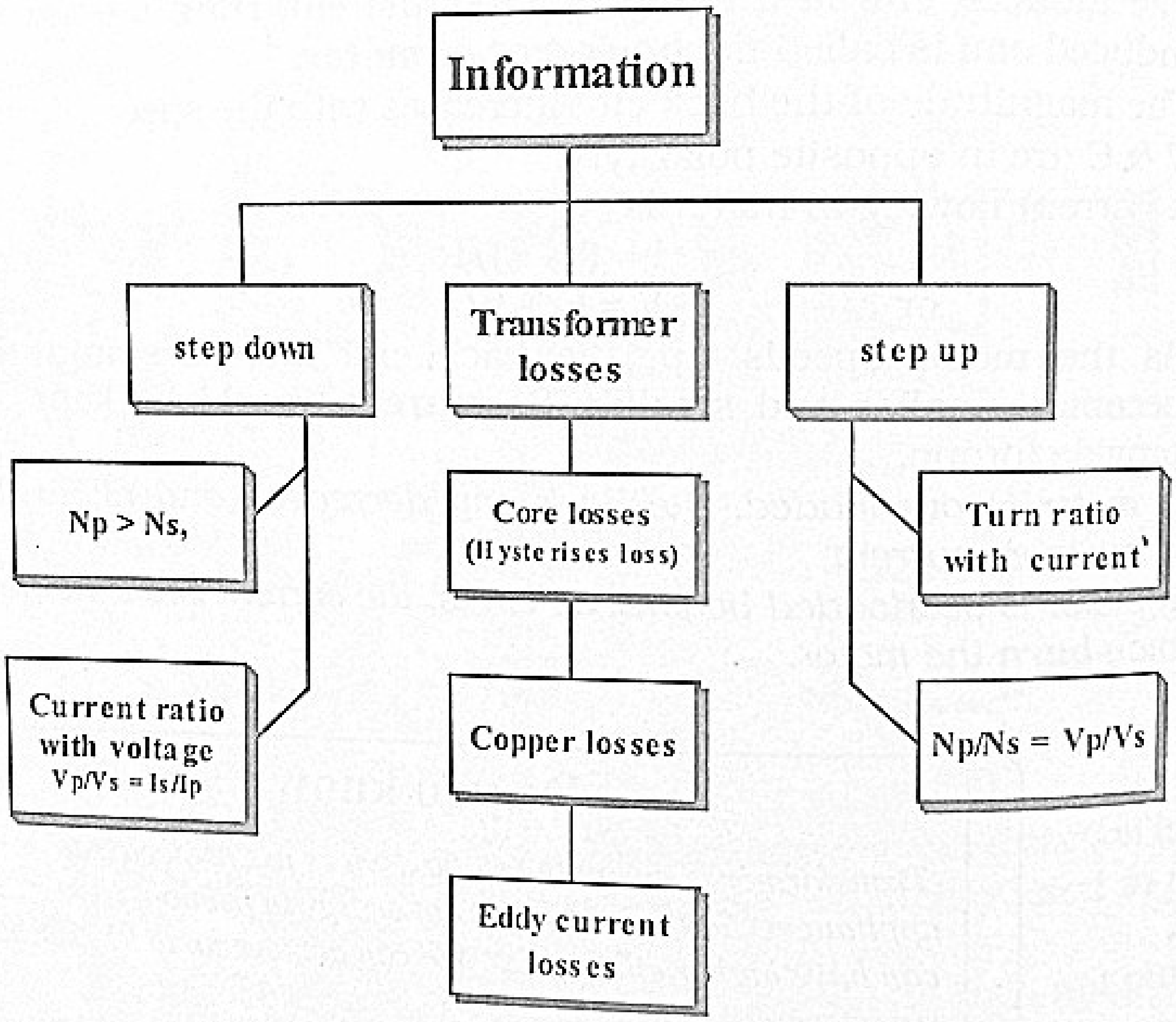
Transformer is one of the static devices in the electrical appliances. So there is no loss of energy in friction. Hence they can have higher efficiencies. We can achieve up to 95% efficient transformer

TRANSFORMER

Transformer is an electromagnetic device used to step up or step down A.C voltage or A.C current, not D.C.

- *Principle of transformer* is a **mutual induction.**
- Coil of transformer where input is applied is called ***primary*** *coil* while other where out put is obtained is called ***secondary coil.***
- *Core* is a material on which coil is wound.
- Core is not solid but laminated.
- Lamination of core is done to reduce **eddy current losses** (eddy current is an induced current produced in a core).





- Transformer can't step up or step down the **energy or power.**
- Transformer consumes very litter part of input power so it can be kept running for hours without considerable loss of power.

$$V_s/V_p = N_s/N_p = I_p/I_s$$

Applications:

- They are used in power distribution in a safe manner from power stations to the utility stations.
- The principle of transmission is that we reduce the value of current via increasing the transmission voltage so saving the cost of copper as less thick wire can full fill the purpose due to small currents.
- Transformers also provide a degree of control of electricity distribution to a town.

TOP Study

Chapter 15 Electromagnetic Induction

PRACTICE EXERCISE

30 mins Time Yourself

(1) The practical illustration of the phenomenon of mutual induction is__________

(a)A.C generator (b)D.C dynamo
(c)motor [✓ (d)transformer]

(2) Weber is the unit of ____________

(a) magnetic field intensity (b) magnetic induction
[✓ (c) magnetic flux] (d) self-inductance

(3) Current produced by moving the loop of wire across a magnetic field is called ___

(a)A.C current (b)D.C current
[✓ (c)induced current] (d)mean square current

(4) emf induced in a circuit according to Faraday's law depends on the _________

(a)maximum magnetic flux $\varepsilon = -\frac{\Phi}{t}$
[✓ (b)rate of change of magnetic flux]
(c)change in magnetic flux
(d)initial magnetic flux

(5) emf generated by A.C dynamo depends upon ____________

(a)number of turns in the coil (b)magnetic field strength
(c)frequency of rotation [✓ (d)all of above]

(6) An alternating current or voltage ____________

(a)fluctuates off and on
(b)varies in magnitude alone
(c)changes its direction again and again
[✓ (d)changes its magnitude continuously and reverses its direction of flow after regularly recurring intervals.]

(7) A dynamo converts __________

[✓ (a)mechanical energy into electrical energy]
(b)electrical energy into mechanical energy
(c)magnetic energy into mechanical energy
(d)magnetic energy into electrical energy

(8) Which one of the following functions, like a motor?

(a)galvanometer (b)ammeter
(c)voltmeter [✓ (d)all of above]

(9) A.C cannot be used for__________

(a)producing heat (b)producing light
(c)magnetizing and electroplating (d)all the above

(10) Which of the following works on torque on the current carrying conductor placed in magnetic field.

(a)galvanometer (b)ammeter
(c)voltmeter [✓ (d)all of the above]

(11) Self inductance of a coil depends upon ______ $LI = \phi N$ $L = \frac{\phi N}{I}$
[✓ (a)current flowing] (b)number of turns per unit length
(c)voltage produce [✓ (d)all]

(12) If the coil is wound on an iron core, the flux through it will______
(a)decrease (b)become zero
(c)remain the same (d)increase

(13) Energy stored in a magnetic field is given by ______
(a)LI^2 (b)$L^2I/2$
[✓ (c)$LI^2/2$] (d)IL^2

(14) Inductors acts as a short circuit for.
(a) AC [✓ (b) DC]
(c) Both (a) and (b) (d) none of these

(15) eddy currents are used in
(a) electromagnetic brakes onle (b)induction furnace only
(c)speedometers only (d)all of the above

(16) Which of the following uses electric energy and does not convert it into any other form?
[✓ (a)transformer] (b)motor
(c)D.C generator (d)A.C generator

(17) The only difference between construction of D.C generator and A.C generator is that of______
(a)carbon brushes (b)coil
[✓ (c)commutator] (d)magnetic field

(18) The answer to which question will distinguish between magnetic and non magnetic materials
(a)is it a metal or non metal
(b)is it a conductor or insulator
(c)can it be given an electric field
(d)does it effect the direction in which a compass needle points

(19) If the secondary coil has N_s turns and the primary N_p turns, the relation between secondary and primary voltages is given by ______
(a)$V_s/V_p=N_p/N_s$ (b)$V_s/V_p = N_s/N_p$
(c)$V_p/V_s=N_s/N_p$ (d)$V_p/V_s=N_pN_s$

(20) Power loss in actual transformer is due to______
(a) Small output
[✓ (b) Eddy currents and magnetic hysterias]
(c) Soft iron core
(d) Back emf

(21) Which of the following prove that a metal bar is a permanent magnet
(a) It attracts another magnet
(b) It attracts both ends of compass needle
(c) It conducts electricity
[✓ (d) It repels another magnet]

(22) The emf induced in a coil by a changing magnetic flux may have unit as______
(a) $ms^{-1}A$ (b) $ms^{-2}A^{-1}$
(c) $kgms^2A^{-1}$ (d) $kgm^2s^{-3}A^{-1}$

---

(23)

(24)

(25)

(26)

(27) In
fiel
(a)
(c)

(28) A.C
(a)
~~(c)~~

(29) A pa
(a) It
(b) Bo
(c) Bo
(d) To

(30) Magn
(a) Sta
(c) Ser

(31) The a
period
(a) 1µs
(c) 10

(32) Which
(a) cur
(c) volt

(33) Which
motor?
(a) Galv
(c) Volt

(34) The ou
turns ra
(a) 1/3
(c) 1

(23) A coil of wire is arranged with its plane perpendicular to a uniform magnetic field of flux density B. when the radius of the coil increases from r_1 to r_2 in time Δt, then what is the emf induced in the coil?

(a) $\pi B/r_2^2-r_1^2)/\Delta t$
(b) $\pi B(r_2-r_1)^2/\Delta t$
(c) $\pi B(r_2^2-r_1^2)/\Delta t$
(d) $\pi B(r_2^2+r_1^2)/\Delta t$

(24) The emf induced in a conductor of unit length moving with unit velocity at right angles to a magnetic field is equal to________

(a) Magnetic flux density
(b) Torque
(c) Mutual induction
(d) Motional emf

(25) A step up transformer has transformation ratio of 3:2. what is the voltage in secondary if the primary voltage is 30V.

(a) 20V
(b) 60V
(c) 45V
(d) 15V

(26) Eddy currents are produced in a material when it is

(a) Heated
(b) Placed in a time varying magnetic field
(c) Placed in an electric field
(d) Placed in a uniform magnetic field

(27) In an electromagnetic wave the electric field vector E and the magnetic field vector B are

(a) Perpendicular to each other
(b) Parallel to each other
(c) 45° to each other
(d) Can have any angle between them

(28) A.C can not be used for__________

(a) Producing heat
(b) Producing light
(c) Magnetizing iron
(d) Producing magnetic field

(29) A particle moving in uniform magnetic field then

(a) Its momentum changes but total energy remain conserved
(b) Both momentum and total energy remain same
(c) Both changes
(d) Total energy change but momentum remain same

(30) Magnetic compass needle will be deflecting, if it is kept near________

(a) Static charge
(b) Soft iron
(c) Semi-conductor
(d) Accelerating charge

(31) The alternating current has frequency of 10^6 Hz, in such a way that time period for completion of cycle is__________

(a) 1μs
(b) 1.5μs
(c) 10^6sec
(d) 1sec

(32) Which of the following quantity remain same in the transformer

(a) current
(b) frequency
(c) voltage
(d) all of these

(33) Which one of the following devices does not function like an electric motor?

(a) Galvanometer
(b) Ammeter
(c) Voltmeter
(d) Transformer

(34) The out put voltage of a transformer is 3 times the input voltage then turns ratio will be__________

$\frac{3x}{x} =$

(a) 1/3
(b) 3
(c) 1
(d) 6

(35) For long distance transmission, the transformer used is ______
(a) Step down
(b) Input voltage and output voltage remain same
(c) Step up
(d) Amplifier is used

(36) Self inductance of a long solenoid is ______

(a) $\mu_0 n^2 \ell A$	(b) $\mu_0 n^2 A/\ell$
(c) $\mu_0 N^2 \ell A$	(d) BA

(37) An electric current induced within the body of a conductor when that conductor either moves through a non uniform magnetic field or in a region where there is a change in magnetic flux is called______

(a) Induced current	(b) Eddy current
(c) Back emf	(d) None of the above

(38) The direction of induced current is such that it opposes the very cause that has produced it. This is law of

(a) Faraday	(b) Lenz
(c) Ampere	(d) Fleming

(39) Transformer works on the principle of ______

(a) Lenz's law	(b) Faraday's law
(c) Mutual induction	(d) Law of conservation of power

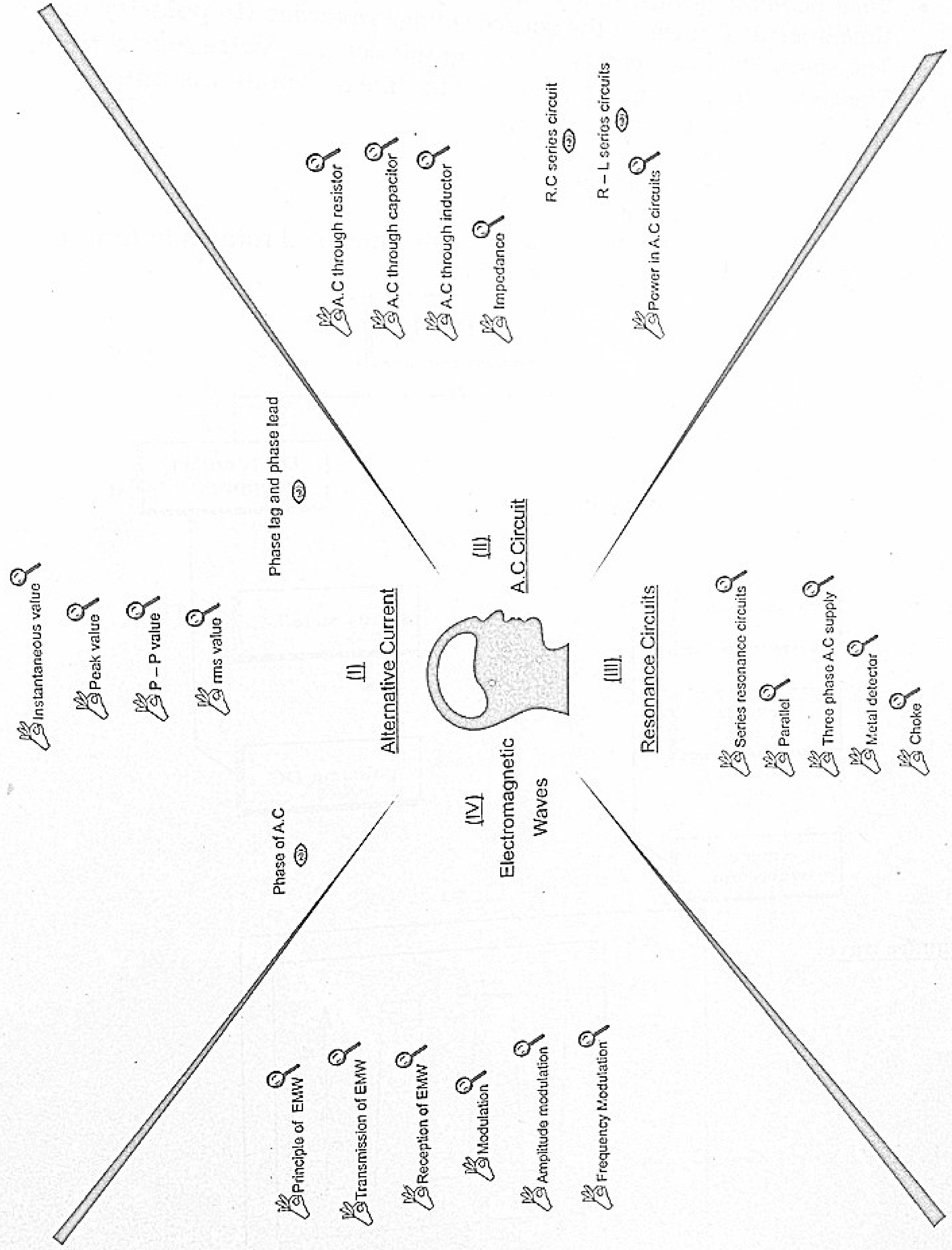
(40) When the motor is at its maximum speed, then back emf will be______

(a) Maximum	(b) Zero
(c) Intermediate values	(d) No back emf

TOP Study

Chapter 16

ALTERNATING CURRENT



INTRODUCTION

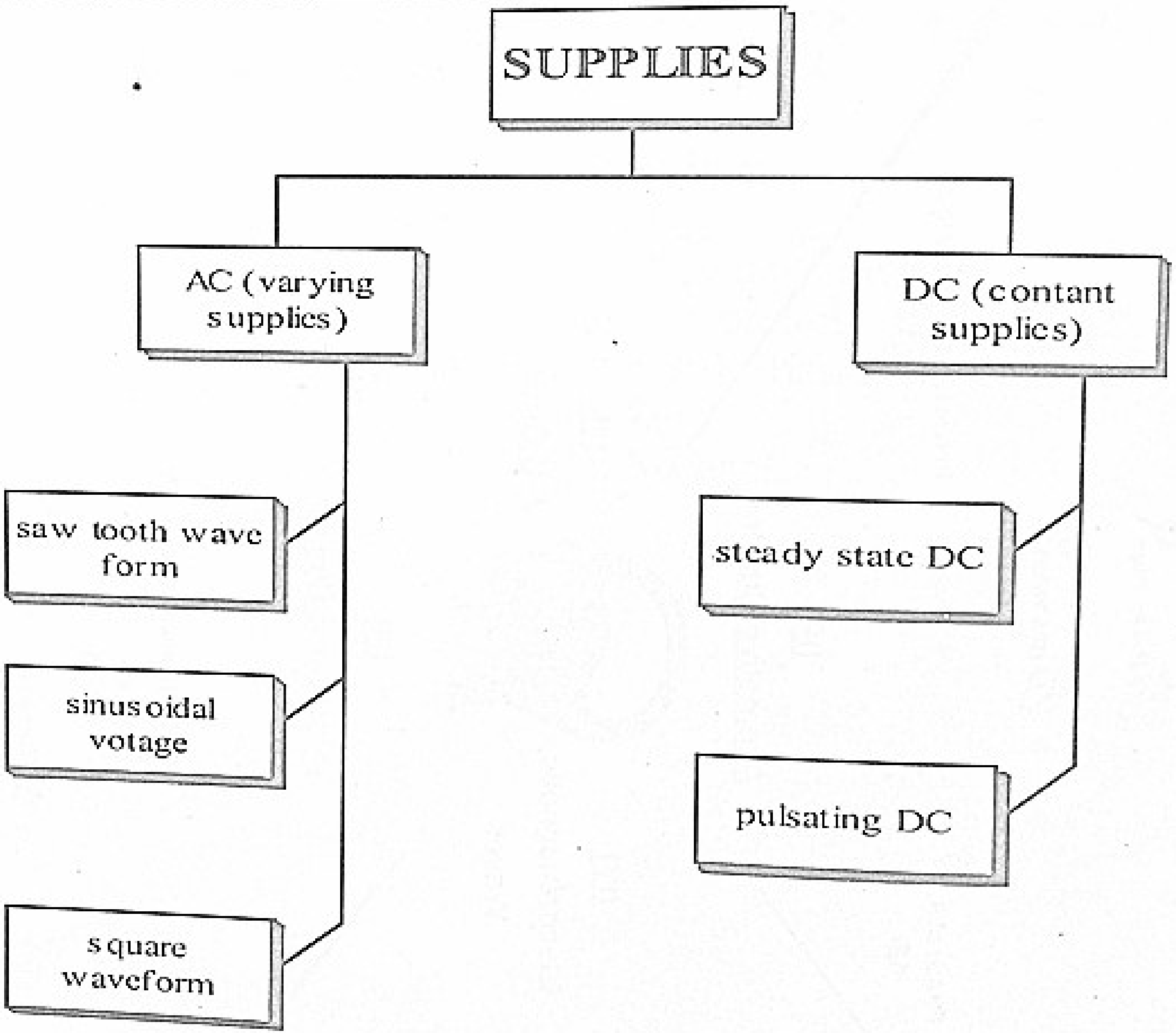
A.C is the current produced by a voltage source that reverses its ***polarity with time.***

- *Time period T of alternating current or voltage* (that produced it) is the time interval T in which the source voltage **reverses its polarity once.**
- The *sinusoidal waveform of A.C* is a graph between **voltage and time.**
- The voltage of A.C generator varies with time and at an instant.

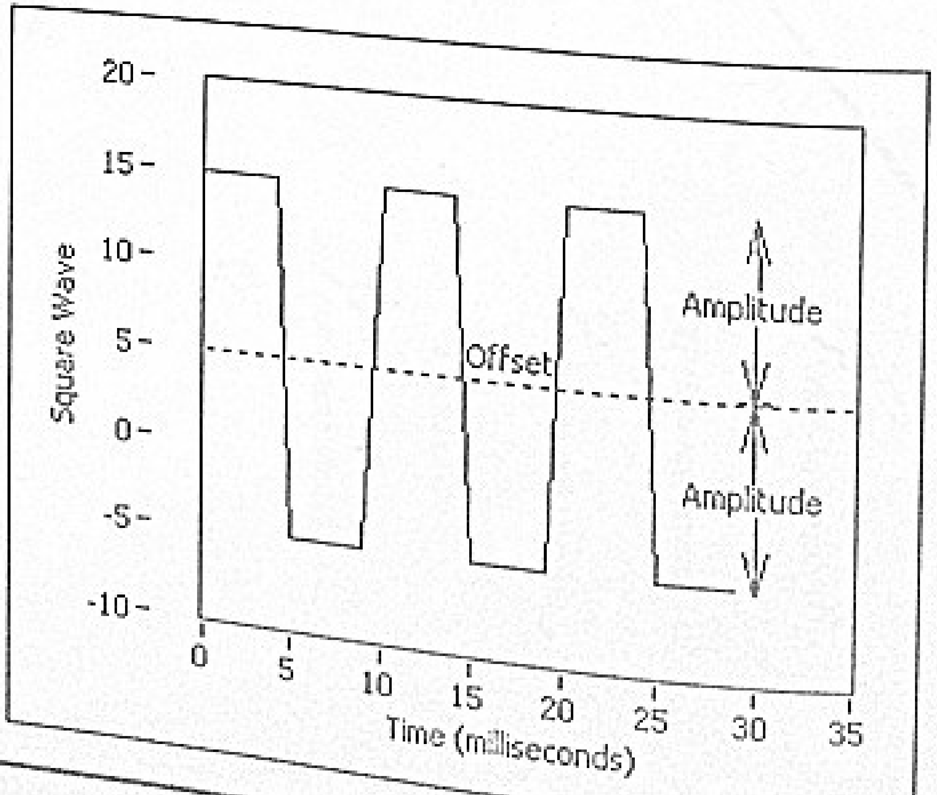
$$V = V_o \sin \omega t$$
$$= V_o \sin 2\pi/T\, t$$
$$= V_o \sin 2\pi f t$$
$$V = V_o \sin\theta$$

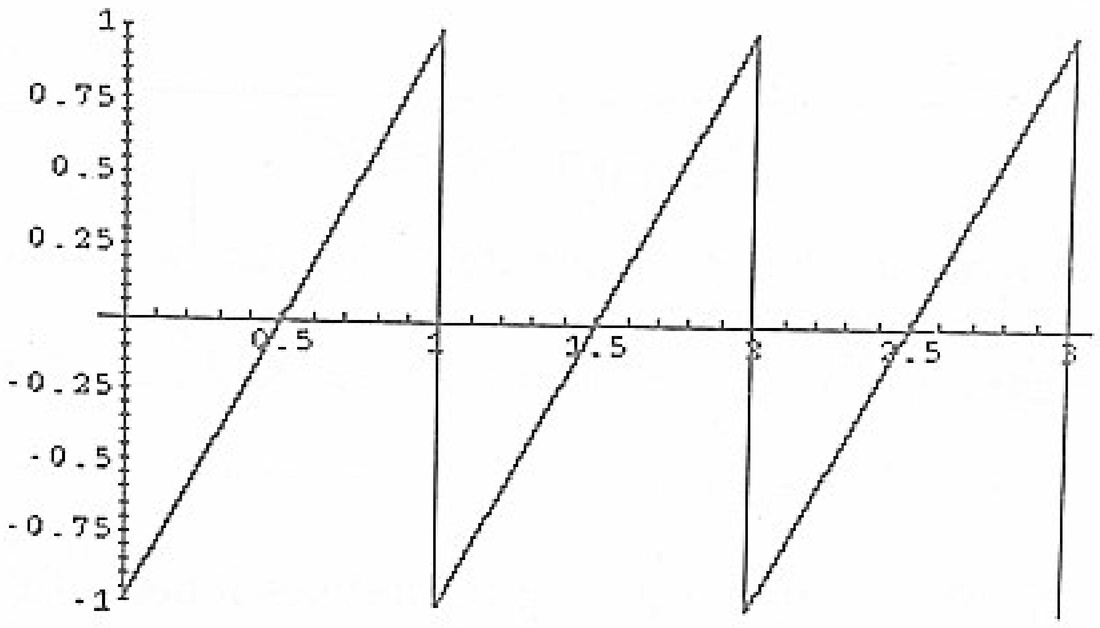
Where $\theta = \omega t$ is the angle through which coil rotates in time 't'.

θ is the phase specifies instant value.

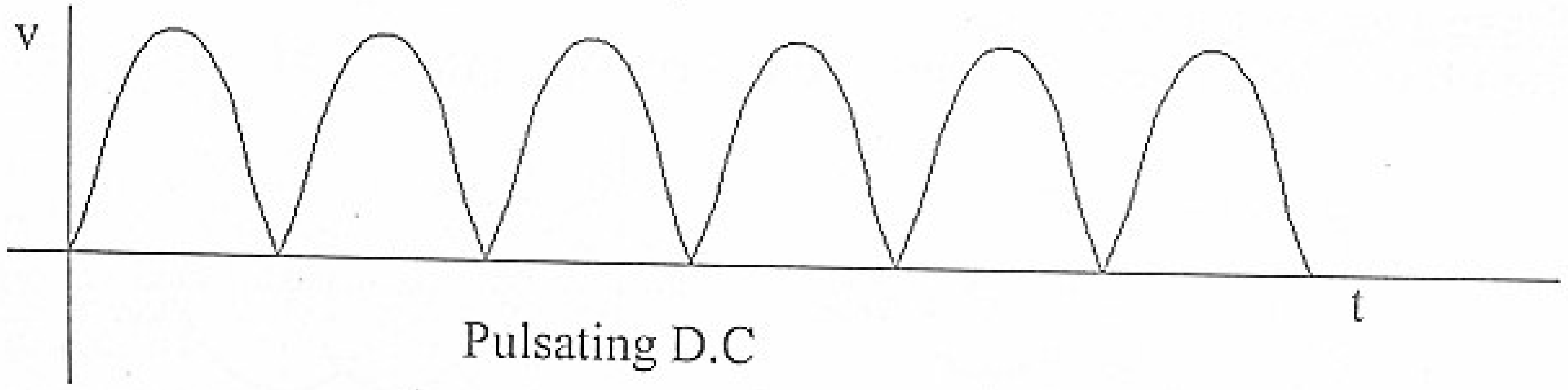


Square wave





Sawtooth wave



Pulsating D.C

Instantaneous Values

The values of voltage or current that exist at any given instant 't' in a circuit is known as instantaneous value.

$V_{inst} = V = V_o \sin\theta = V_o \sin 2\pi ft = V_o \sin\omega t$

or $I_{inst} = I = I_o \sin\theta = I_o \sin 2\pi ft = I_o \sin\omega t$

V is the instantaneous value between $+V_o$ & $-V_o$

- *Sinusoidal graph* is the set of all instantaneous values.

Peak value (V_o or I_o)

It is the highest value for ***voltage or current***

Peak to Peak Value

It is the sum of +ve & -ve peak values i.e. $+V_o + (-V_o) = 2V_o$

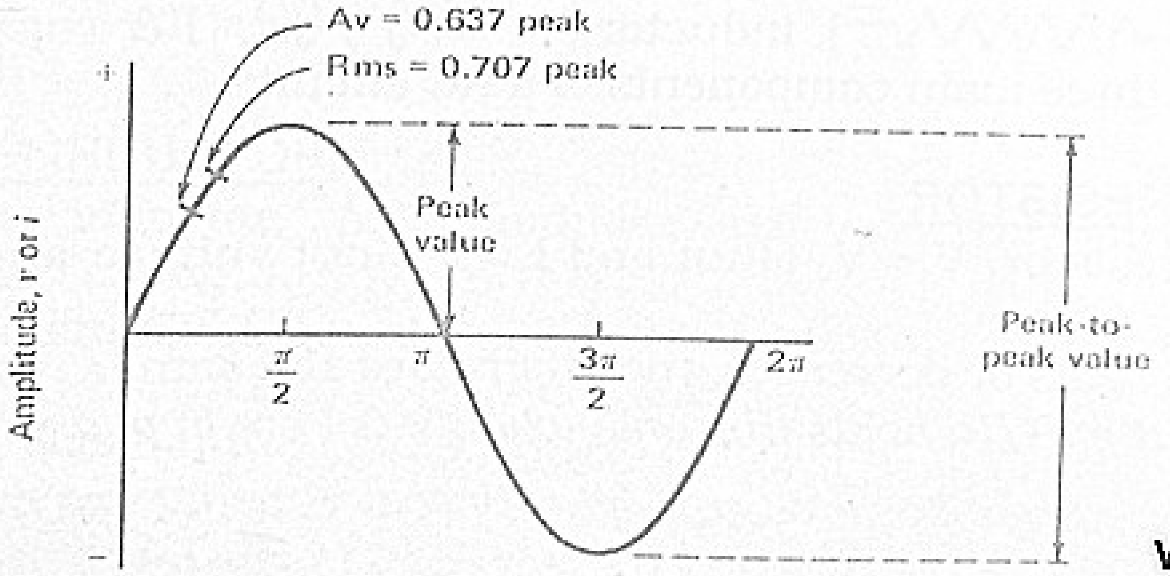
Root mean square (rms) value:-

It is the square root of the average of squared voltage or current.

$V_{rms} = V_o/\sqrt{2} = 0.707V_o$

$I_{rms} = I_o \sqrt{2} = 0.707I_o$

rms value is also called effective value.



TOP Study

Chapter 16

Alternating Current

Do you know?

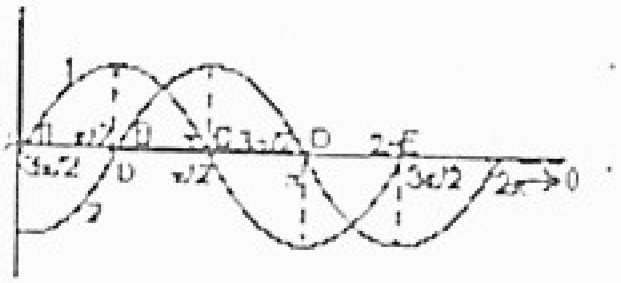
The average value of a sinusoidal symmetrical signal is zero over a cycle but RMS value is not. That is why practically all the calculations are based on RMS value.

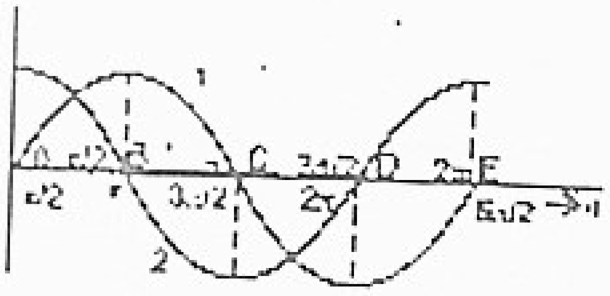
Phase

The angle θ which specifies the instantaneous value of alternating voltage or current is known as its phase.

Phase Lag and Phase lead

The phase difference between two alternating qualities is shown in figure.





- Phase lag occurs when the phase of waveform 2 is less then the phase waveform 1.
- Phase lead occurs when the phase of waveform 2 is greater then the phase of waveform 1.

Representing Phases and Alternating Quantities by Vectors

A counter ***clockwise rotating vector*** graphically represents a **sinusoidally alternating** voltage or current.

VECTOR DIAGRAM

A set of counter clockwise rotating vectors whose lengths represents the peak values or rms value of the signals and the angle between them represents the change of phase in AC signals is collectively called as vector diagram.

D.C CIRCUIT

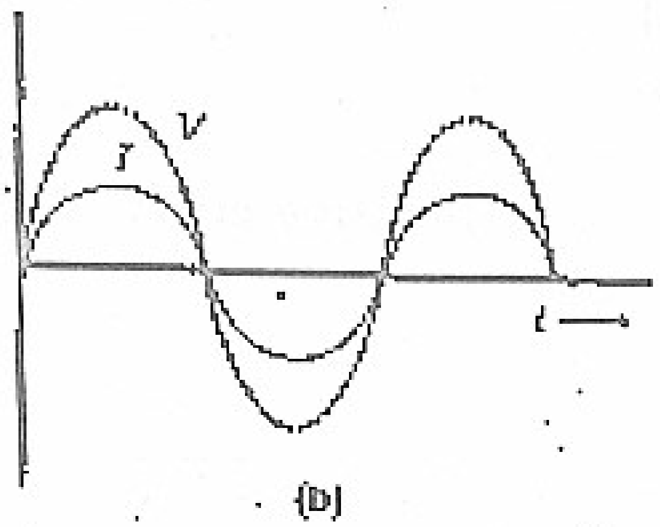
- Resistor R is the basic circuit element in D.C circuit.
- R controls voltage and current
- Ohm's law can be used.

A.C CIRCUIT

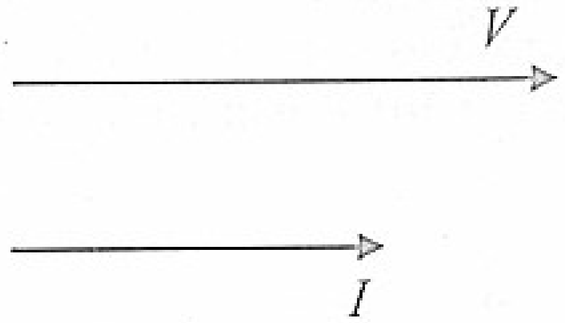
- Resistor (—\/\/\/\/—), inductor (—0000—) & capacitor (—| |—) These are three main components of a AC circuit:-

A.C THROUGH RESISTOR

- Through resistor, $V = V_o \sin\omega t$ and $I = I_o \sin\omega t$ **voltage and current** are **in phase.**
- If one increases or decreases, the other **does the same.**
- *$P = VI = I^2R = V^2/R$, holds true only when V & I are in phase.*



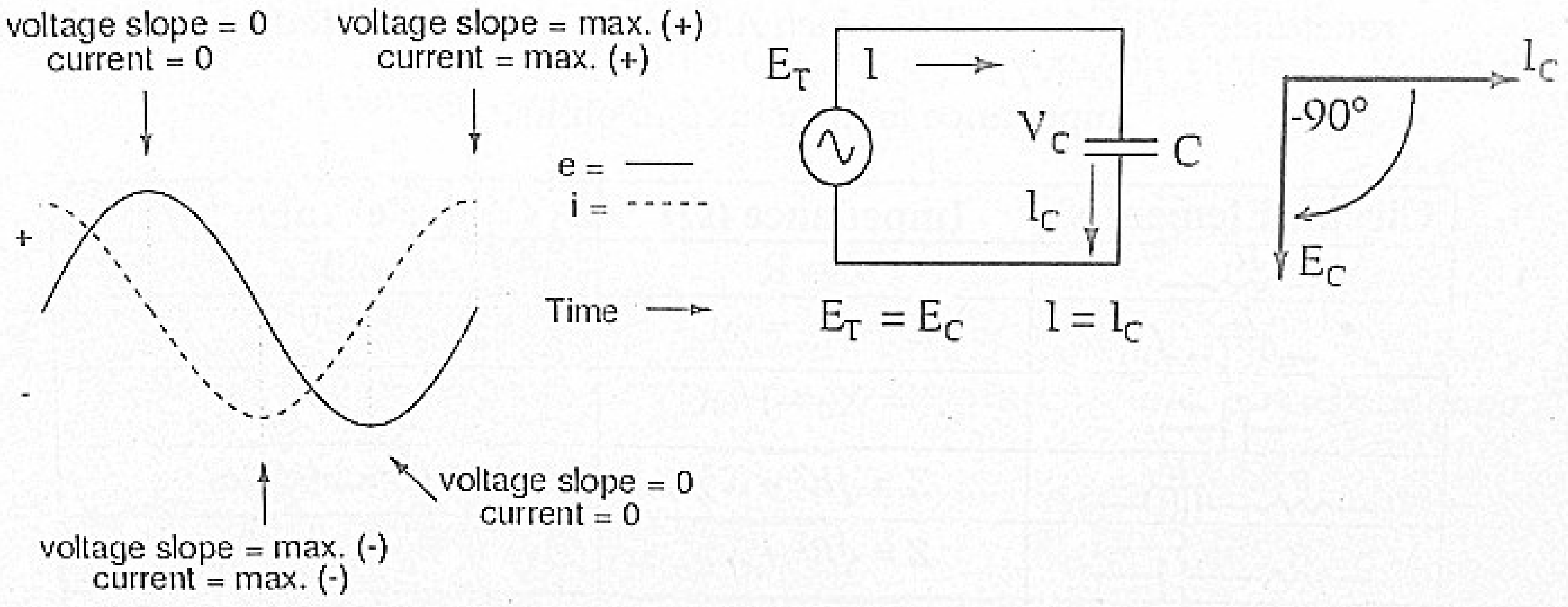
(b)



A.C THROUGH CAPACITOR

- Due to D.C, a capacitor behaves as insulator. It only stores charge.
- *Due to A.C, a capacitor behaves as conductor.*
- Through capacitor, charge built up between parallel plates of a capacitor, $q = CV_o \sin\omega t$
- Current leads voltage by phase $\theta = 90^\circ$ or $\pi/2$
- A.C can pass through capacitor (seems passing) because of the continuously reversing polarity.
- Reactance = measure of opposition of capacitance to flow of A.C.
- Reactance is measured in ohms

  $$X_c = V/I = 1/2\pi fC = 1/\omega C$$
- As frequency increases Xc decreases.



Voltage lags current by 90° in a pure capacitive circuit

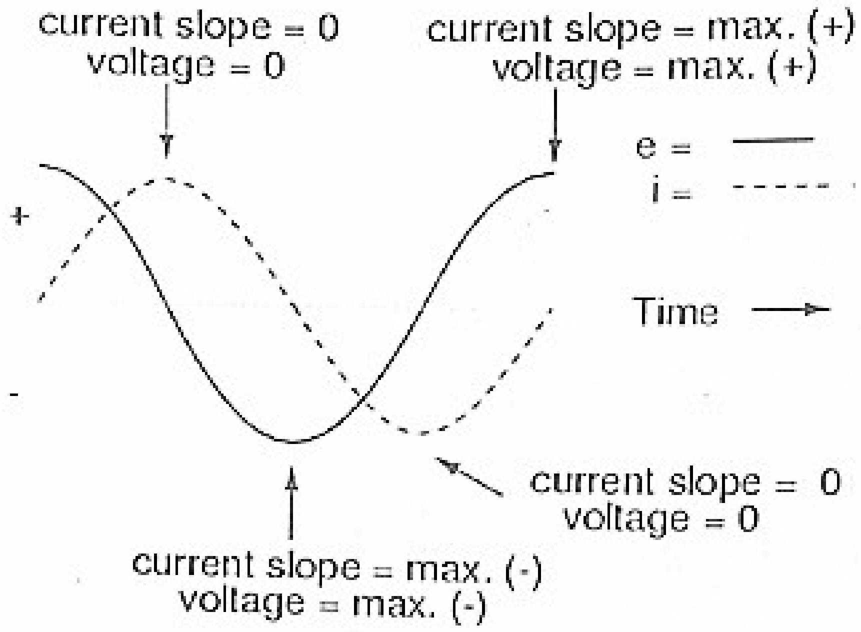
A.C THROUGH INDUCTOR

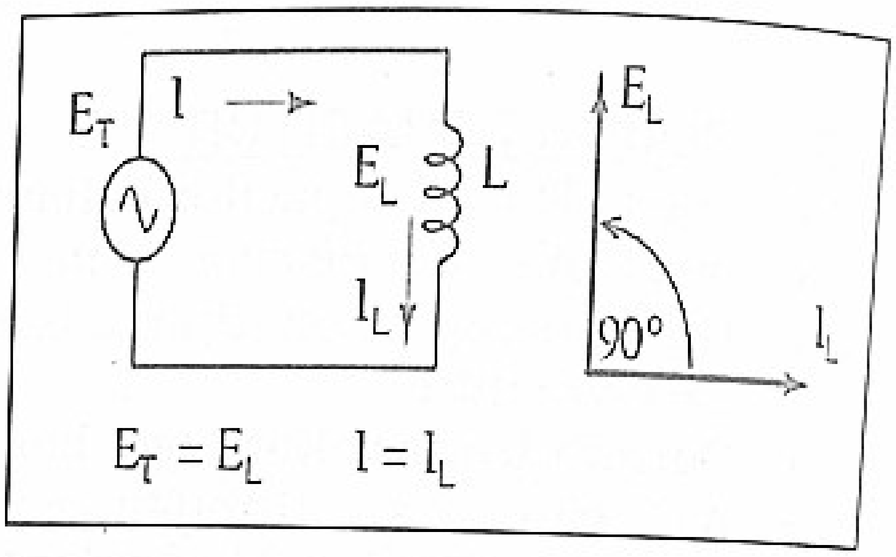
- Through inductor, A.C produces self-inductive effects because it constantly changes.
- When potential difference is applied back emf is produced.

  $$\epsilon_L = L\Delta I/\Delta t\ ,\ V = L\Delta I/\Delta t$$
- Current **lags behind** voltage by 90° or $\pi/2$.
- Inductive reactance is measure of opposition offered by the inductor coil to the flow of A.C.

$$X_L = V/I = 2\pi f L = \omega L$$

- *As frequency increases X_L increases*
- *In a pure inductor, energy gained = energy given out*
- **No power loss in pure inductive or capacitive circuit takes place.**





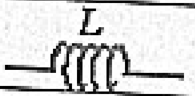
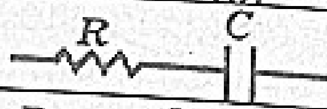
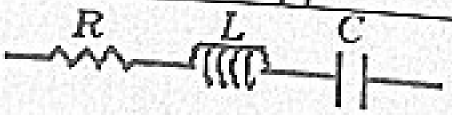
Current lags voltage by 90° in inductive circuit.

IMPEDANCE (Z)

Resulting effect of resistance R, capacitive reactance X_c & inductive reactance X_L in a circuit in which A.C is ***provided is called impedance.***

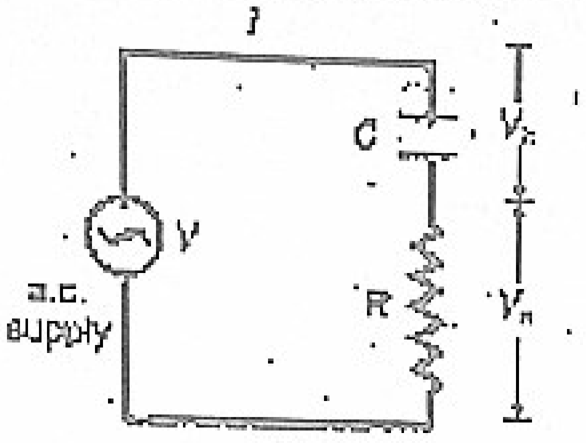
$Z = V/I$

Impedance is measured in ohms.

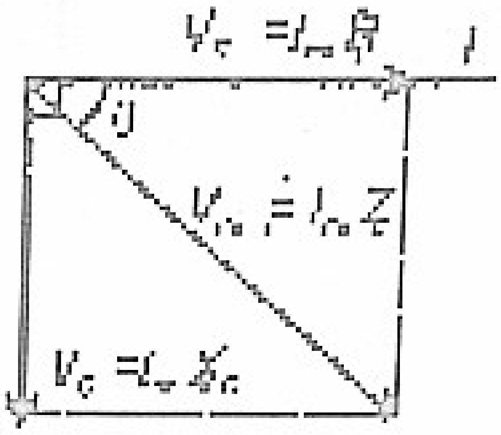
Circuit Element(s)	Impedance (Ω)	Phase Angle (φ)
R	$Z = R$	0°
 L	$Z = X_L = \omega L$	+90°
C	$Z = X_C = 1/\omega C$	-90°
R L	$Z = \sqrt{R^2 + X_L^2}$	$0° < \phi < 90°$
 R C	$Z = \sqrt{R^2 + X_C^2}$	$-90° < \phi < 0°$
 R L C	$Z = \sqrt{R^2 + (X_L - X_C)^2}$	$\phi > 0°$ if $X_L > X_C$ $\phi = 0°$ if $X_L = X_C$ (Resonance) $\phi < 0°$ if $X_L < X_C$

R-C SERIES CIRCUIT

- Impedance $Z = V/I = \sqrt{R^2 + (1/\omega C)^2}$
- Phase between V & I is $\theta = \tan^{-1}(1/\omega CR)$
- *Current leads* ***voltage.***

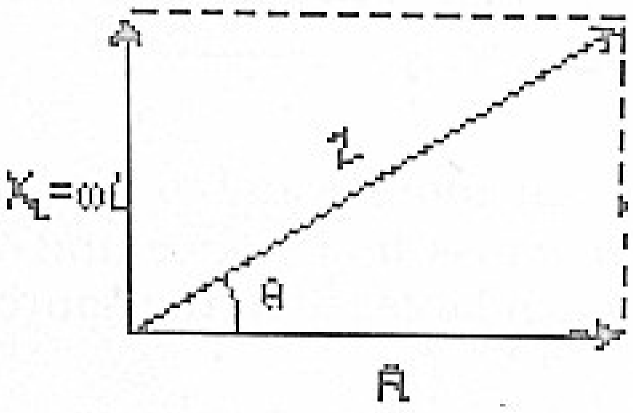


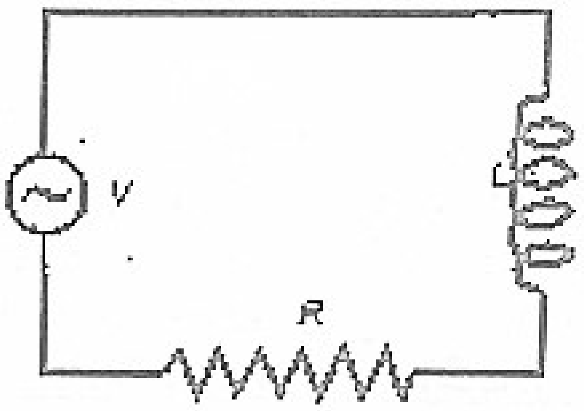
(a)



R-L SERIES CIRCUIT

- Impedance $Z = V/I = \sqrt{R^2+(\omega L)^2}$
- Phase between V & I is $\theta = \tan^{-1}(\omega L/R)$
- *Current lags voltage*



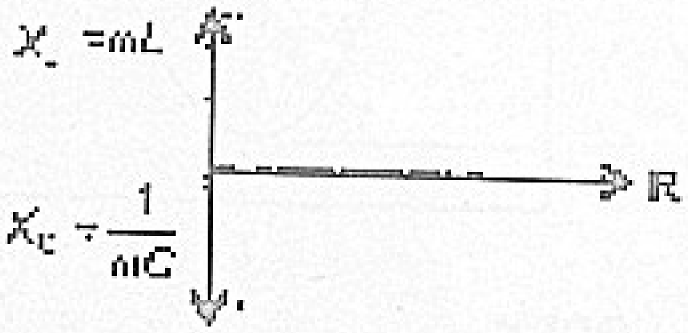


POWER IN A.C CIRCUIT

- *Power dissipation = 0,* in purely **inductive & capacitive circuit**
- P = VI only when V & I are in phase in a purely resistive circuit.
- *P = IV cosθ* in real L & C circuit where cosθ is power factor & Vcosθ is component voltage vector **along current.**

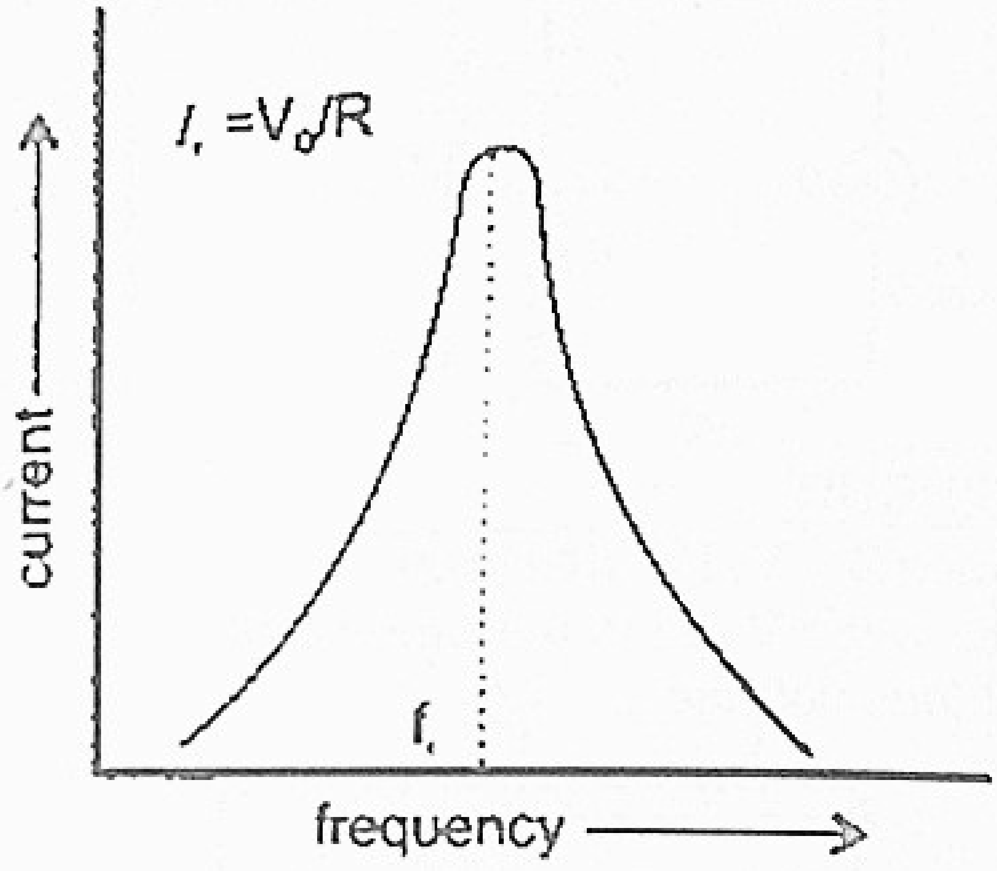
SERIES RESONANCE CIRCUIT

- $X_L = \omega L$ and $X_C = \dfrac{1}{\omega C}$
- *At low frequency capacitance* ***dominates*** *and circuit behave as R-C series circuit and at high frequency inductance* ***dominates and circuit behave as R-L series circuit.***
- The impedance diagram is shown in figure



- If $X_L = X_C$, then it is 'resonance' and frequency at this time is called ***resonance*** *frequency.*

$$\omega_r L = 1/\omega_r C$$
$$f_r = 1/2\pi\sqrt{LC}$$



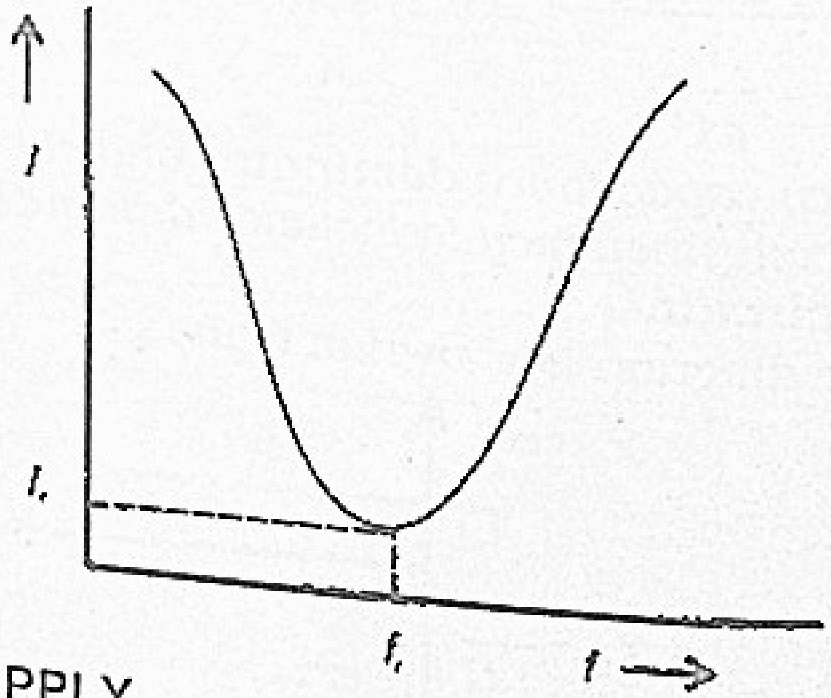
- At resonance, impedance is minimum and is equal to R.
- At resonance V_L, the voltage drop across inductance and V_C the voltage drop across capacitance may be much larger than the source voltage.

PARALLEL RESONANCE CIRCUIT

- The resonance frequency is

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

- At resonance the impedance is maximum . Hence current is minimum at resonance and **in phase** with voltage.
- At resonance branch currents may be larger than source currents.
- At resonance power factor is one



THREE PHASE A.C SUPPLY

- In three phase A.C generator, there are three coils inclined at 120° angle to each other.
- Each coil is connected to its own **pair of slip** rings.
- In three-phase supply, total load is divided in three parts.
- *There will be no drop of voltage supply in three phases.*
- *Three-phase supply can provide 400V between two lines.*
- *The line to neutral voltage is 230v.*

- *Star type connection is used to connect three phase wires and one neutral wire.*

PRINCIPLE OF METAL DETECTOR

- Coil (L) & Capacitor (C) are coupled to produce **oscillations of currents.**
- *L-C circuit behaves like an oscillating* ***mass spring system.***
- Energy oscillates between a capacitor and inductor called *an electrical oscillator.*
- *L-C circuit* produce **beats phenomenon** for metal detection.

CHOKE

- It is *an inductive coil.*
- It consumes extremely **small power.**
- It is used in A.C circuit to limit current.

ELECTROMAGNETIC WAVES (EMW)

- Electromagnetic waves were *predicted by Maxwell and experimentally proved by* ***Frank Hertz.***
- Electromagnetic waves are ***oscillating electric and magnetic fields***
- Changing magnetic flux produces electric field given by:

  $E = (1/2\pi r)\ \Delta\Phi m/\Delta t$

- Changing electric flux produces magnetic field given by:

  $B = (\mu_o\epsilon_o/2\pi r)\qquad \Delta\Phi_e/\Delta t$
- Speed of e.m waves in vacuum is given by

  $V = 1/\sqrt{\mu_o\epsilon_o} = 3x10^8 msec^{-1}$
- The frequency is about **10^6Hz depending upon wavelengths.**

PRODUCTION OF E.M WAVES

- e.m waves in laboratory are produced by **oscillation of electrons.**
- Frequency of oscillatory circuit is

  $f = 1/2\pi\sqrt{LC}$

RECEPTION OF E.M WAVES

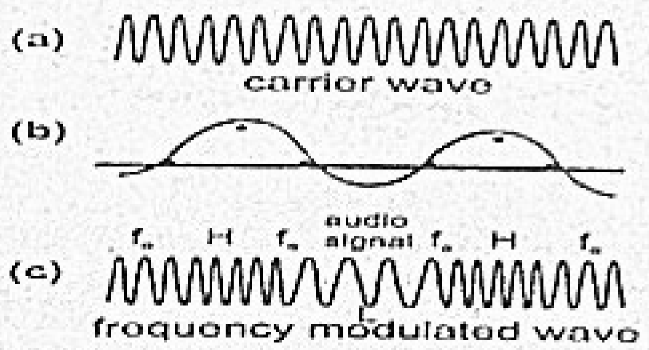
The reception of EMW is based on a LC circuit in which the value of inductance is fixed but varying capacitance gains different frequencies.

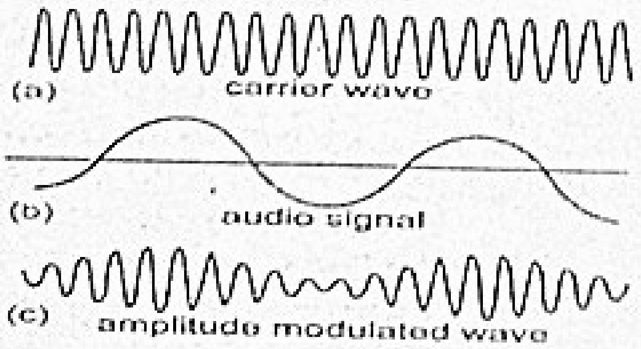
MODULATION

The process of mixing the low frequency signal (sound) with high frequency radio waves is called ***modulation.***

The resultant wave is called ***carrier wave.***

- *Types*





  - ✓ Amplitude modulation (A.M)
  - ✓ Frequency modulation (F.M)
  - ✓ Phase modulation. (P.M)

- *Modulated waves are demodulated by receiving sets (TV or radio set), rectified and then detected.*
- Detection of modulated wave takes place only when frequency of tuning circuit equals to that of transmitting circuit and **hence electrical resonance is produced.**

Do you know?

- *Range of A.M signal 540KHz to 1600KHz*
- *Range of F.M signal 88MHz to 108MHz*
- *F.M signal does not contain any noise signal as the A.M.*

PRACTICE EXERCISE

30 min Time Yourself

(1) A choke is used as a resistance in ________
(a) DC circuit (b) AC circuits
(c) Both AC and DC circuit (d) Full wave rectifier circuit

(2) At resonance the value of the power factor in an L-C-R series circuit is________
(a) Zero (b) ½
(c) 1 (d) not definite

(3) An A.C series circuit containing 4Ω resistance and 3-Ω inductive reactance. The impedance of the circuit is ________
(a) 1 Ω (b) 5 Ω
(c) 7 Ω (d) 7/√2 Ω

(4) An inductive coil has a resistance of 100Ω. When an AC signal of frequency 1000Hz is fed to the coil, the applied voltage leads the current by 45°. What is the inductance of the coil?
(a) 10mH (b) 12mH
(c) 16mH (d) 20mH

(5) Choose the correct statement. In the case of AC circuit, ohm's law holds for ________
(a) Peak values of voltage and current
(b) Effective values of voltage and current
(c) Instantaneous values of voltage and current
(d) All of the above

(6) The phase angle between the voltage and the current in an AC circuit consisting of a resistance is ________
(a) Zero (b) 45°
(c) 90° (d) 180°

(7) In an LCR series circuit, if V is the effective value of the applied voltage, V_R is the voltage across R, V_L is the effective voltage across L & V_c is the effective voltage across C then ________
(a) $V = V_R+V_L+V_C$ (b) $V^2=V_R^2+V_L^2+V_C^2$
(c) $V^2=V_R^2+(V_L-V_C)^2$ (d) $V^2=V_L^2+(V_R-V_C)^2$

(8) When a voltage $V = V_o \cos \omega t$ is applied across a resistor of resistance R, the average power dissipated per cycle in the resistor is given by________
(a) $V_o/\sqrt{2}\,R$ (b) $V_o/\sqrt{2}\omega R$
(c) $V_o^2/2R$ (d) $V_o^2/2\omega R$

$\longrightarrow R$

$\longrightarrow V$

$V_{av} = \frac{0+V}{2} = \frac{1}{2}V$. So $\cos\theta = 1$

$\therefore \boxed{P = 1V}$

$P = \frac{V^2}{R}$

$P = \frac{1}{2}\frac{V^2}{R}$

(9) Two identical coaxial circular loops carry equal currents in the same direction. If the loops approach each other, the current in ________
(a) Each increases
(b) Each decreases
(c) Each remains the same
(d) One increases whereas that in the other decreases

$f = 2\pi\sqrt{LC}$

(10) An inductor may store energy in ________
(a) its electric field (b) its coils
(c) its magnetic field (d) both electric and magnetic fields

(11) Average value of current and voltage over a cycle is
(a) Positive (b) negative
(c) both (d) zero

(12) A changing magnetic flux produces around itself an induced ______
(a) Magnetic field (b) Electric field
(c) Electromagnetic force (d) Artificial gravitational field

(13) Maxwell derived mathematically that the velocity of the electromagnetic waves is ________
(a) $1/\epsilon_o$____ (b) $1/\sqrt{\mu_o/\epsilon_o}$______
(c) $\sqrt{\mu_o\epsilon_o}$____ (d) $1/\sqrt{\mu_o\epsilon_o}$_____

(14) Electromagnetic waves travel in free space with the speed of ______
(a) γ-rays (b) Positive rays
(c) Cathode rays (d) β-rays

(15) The direction of propagation of an electromagnetic waves is ______
(a) Perpendicular to electric field
(b) Perpendicular to both electric and magnetic field
(c) Perpendicular to magnetic field
(d) Parallel to electric and magnetic field

(16) An electromagnetic wave consists of ________
(a) Electric and magnetic fields moving parallel to each other
(b) Magnetic field moving with velocity of light in space
(c) Electric field moving with velocity of light
(d) Electric and magnetic fields moving perpendicular to each other

(17) Electromagnetic waves transport ______
(a) Energy (b) Mass
(c) Heat (d) None

(18) Waves emitted from the antenna are ________
(a) Sound waves (b) Electromagnetic waves
(c) Radio waves (d) Modulated waves

(19) A choke coil has
(a) High inductance and high resistance
(b) High inductance and low resistance
(c) Low inductance and high resistance
(d) Low inductance and low resistance

(20) Natural or resonant frequency of an LC circuit is ______
(a) $1/4\pi\sqrt{LC}$ (b) $2\pi\sqrt{LC}$
(c) $1/\sqrt{LC}$ (d) $1/2\pi\sqrt{LC}$

(21) If capacitance of L-C circuit is made four times then frequency of the circuit becomes ________
(a) Twice (b) One half
(c) Four times (d) None

$f = \frac{1}{2\pi\sqrt{LC}}$

(22) A capacitor of capacitance 30μF is charged by a constant current of 10mA. If initially the capacitor was uncharged, what is the time taken for the potential difference across the capacitor to reach 300V?
(a) 0.9sec (b) 15sec
(c) 1.5×10^5sec (d) 0.9×10^{-2}sec

(23) The value of the steady current, which when flowing through the same resistor produces heat at the same rate as the mean rate of heat produced by the alternating current, is __________

(a) Average current
(b) Sinusoidal current
[✓ (c) r.m.s current]
(d) Net current

(24) To find the r.m.s value of an alternating current mathematically, we need to have ________

(a) Mean value of I^2
[✓ (b) Square root of mean value of I^2]
(c) Square root of I^2
(d) Square of $I/2$

(25) An alternating current of r.m.s value of 4.0 A and frequency 50Hz flows in a circuit containing 10Ω resistor. The peak current is then _______

(a) 20A
(b) 20.66A
(c) 6.66A
[✓ (d) 5.66A]

(26) An alternating current of r.m.s value of 2A and a steady direct current I flowing through identical resistors dissipate heat at the same rate. What is the current I?

[✓ (a) 2A]
(b) $\sqrt{2}$A
(c) 1A
(d) $2\sqrt{2}$A

(27) An alternating current is represented by the equation $I = I_0\sin\omega t$, which of the following equation represents an alternating current of frequency and amplitude twice that of the above current?

(a) $I = 2I_0\sin(\omega t/2)$
[✓ (b) $I=2I_0\sin(2\omega t)$]
(c) $I=2I\sin\omega t$
(d) $I=I_0\sin(2\omega t)$

(28) In pure resistor circuit, the voltage and current are __________

(a) Lagging each other
(b) They are at 90° phase difference
[✓ (c) They have zero phase difference]
(d) No phase difference

(29) The power factor of an ac circuit has the value

(a) Unity when the circuit contains only an inductance
[✓ (b) Unity when the circuit contains only a resistance]
(c) Unity when the circuit contains resistance and capacitor
(d) Unity when the circuit contains only a capacitance

(30) In capacitive circuit, the current __________

(a) Lags behind voltage by $\pi/2$
(b) Is in phase with voltage
(c) Opposite in phase of voltage by π
[✓ (d) Leads forward the voltage by $\pi/2$]

(31) A 100μF capacitor with 12V source in series having frequency 50Hz, will offer a capacitive reactance of about __________

[✓ (a) 32Ω]
(b) 60 Ω
(c) 50 Ω
(d) 100 Ω

(32) If a glass plate is inserted in between the plate of a capacitor in series with a lighted bulb, the brightness of the bulb __________

(a) Remains same
[✓ (b) Brightness increases]
(c) Brightness decreases
(d) No light

(33) A pure variable resistor is connected in series with a pure capacitor of fixed capacitance. The impedance of the circuit ________
(a) Remains (b) Becomes infinite
(c) Becomes zero [✓ (d) Increases]

(34) A wire of resistance R is coiled inductively so that its inductance is L. The impedance of the coil at a frequency of f is ________
(a) $(R+2\pi fL)^{1/2}$ (b) $R+1/2\pi fL$
(c) $(R^2+f^2L^2)^{1/2}$ [✓ (d) $(R^2+4\pi^2f^2L^2)^{1/2}$]

(35) Ammeter connected in an AC circuit measures ________
(a) Exact value of current [✓ (b) rms value of current]
(c) Net value of current (d) Peak value of current

(36) When a pure inductor of inductance L, and a pure capacitor of capacitance C are connected in parallel to a sinusoidal potential difference V, the potential difference across both L&C will be ________
[✓ (a) Same] (b) Different
(c) At L will be more than at C (d) At L will be less than at C

(37) An ideal choke would be
(a) Pure capacitor
[✓ (b) Pure inductor]
(c) Pure resistor
(d) Combination of inductor and capacitor

(38) What is the self inductance of a coil in which an induced emf of 2V is set up when the current changes at the rate of 4 As^{-1}?
(a) 0.5mH [✓ (b) 0.5H]
(c) 2.0H (d) 8.0H

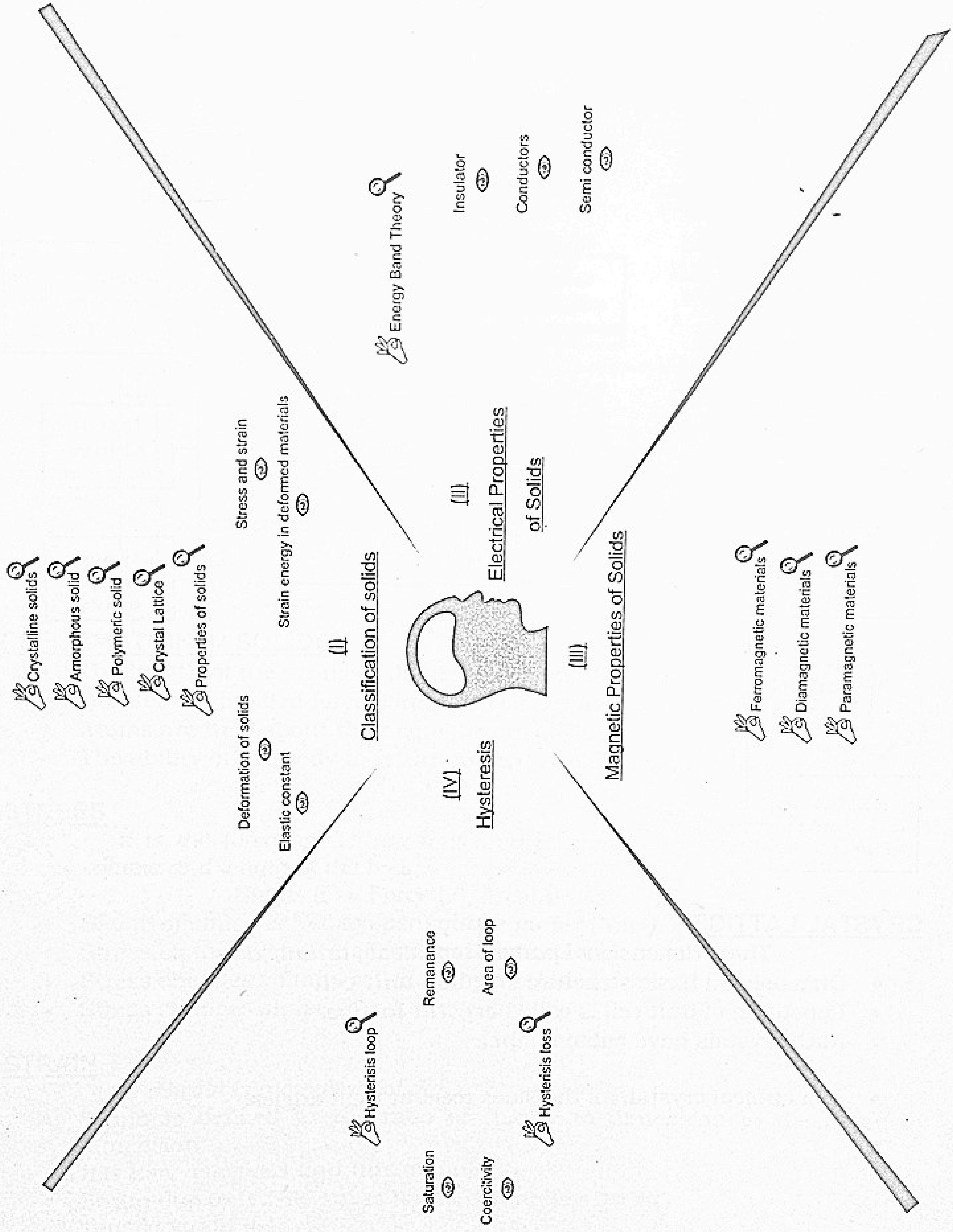
(39) The frequency of a circuit consisting of a capacitance C and a resistor R is ________
(a) C/R (b) R/C
[✓ (c) 1/RC] (d) $1/\sqrt{RC}$

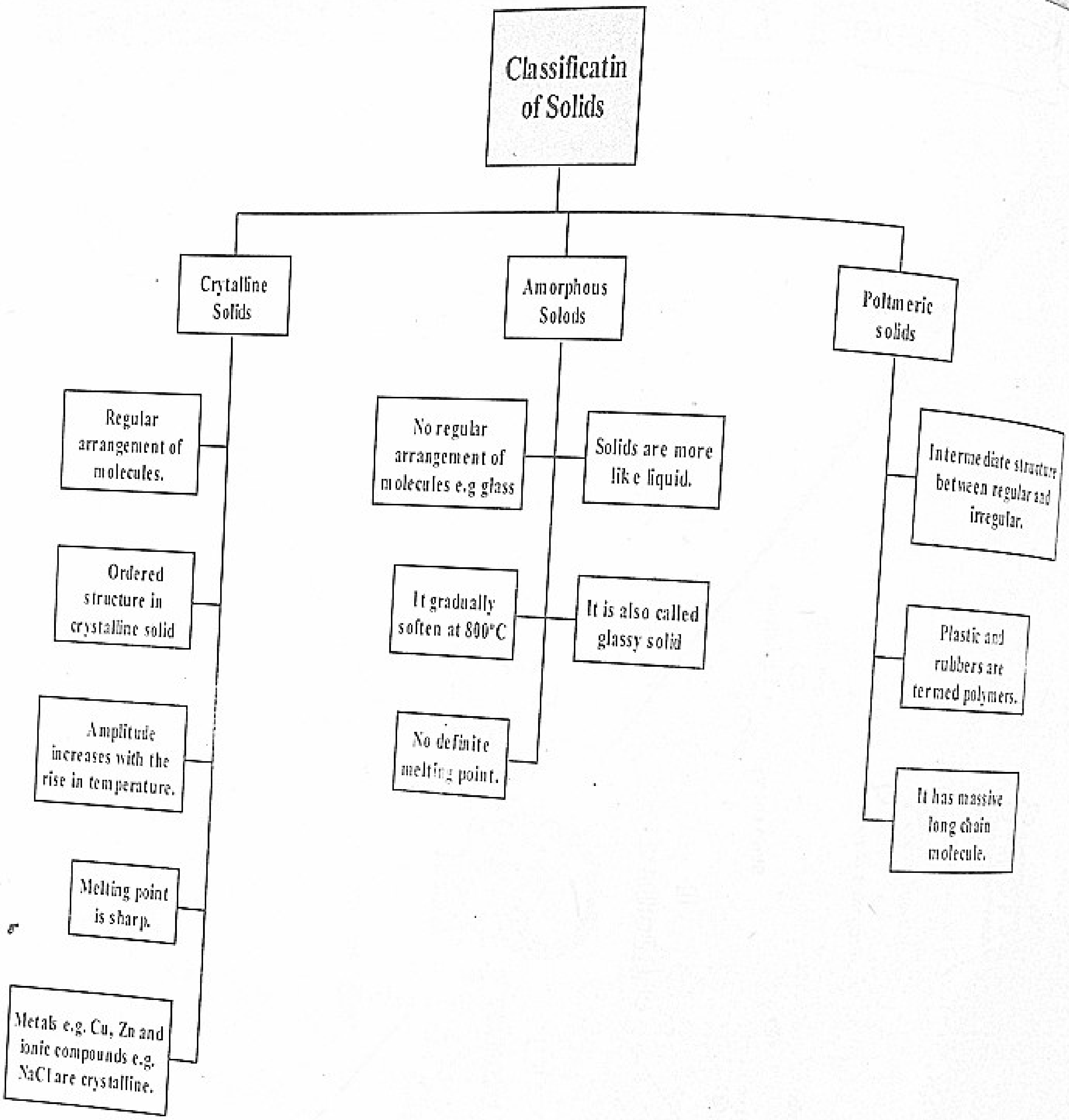
(40) A 10Ω electric heater is connected to a 220V, 50Hz mains supply. What is the peak value of the potential difference across the heater element?
(a) 220V (b) $220/\sqrt{2}$V
(c) 110V [✓ (d) $220\sqrt{2}$V]

TOP Study

Chapter 17

PHYSICS OF SOLIDS




Classificatin of Solids
Crytalline Solids
Amorphous Solods
Poltmeric solids
Regular arrangement of molecules.
Ordered structure in crystalline solid
Amplitude increases with the rise in temperature.
Melting point is sharp.
Metals e.g. Cu, Zn and ionic compounds e.g. NaCl are crystalline.
No regular arrangement of molecules e.g glass
Solids are more like liquid.
It gradually soften at 800°C
It is also called glassy solid
No definite melting point.
Intermediate structure between regular and irregular.
Plastic and rubbers are termed polymers.
It has massive long chain molecule.

CRYSTAL LATTICE

Three-dimensional pattern repeatedly arranged

- Dimensional basic structure is called **unit cell**
- Repetition of unit cell is called **crystal lattice.**
- NaCl crystals have **cubic shape.**
- In a cubical crystal, all the sides meet at right angles.

DEFORMAT
- The le
- Greate
- Atoms
- The ab

STRESS

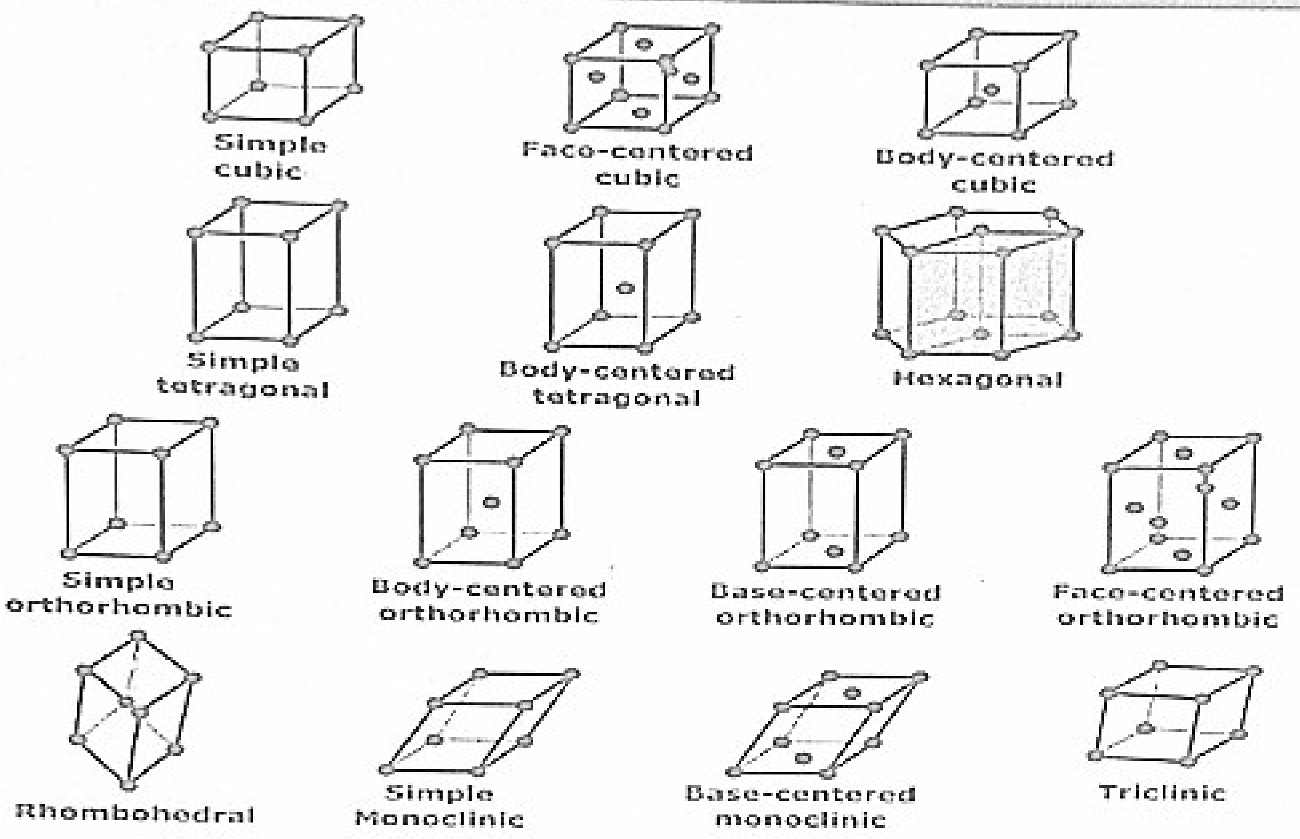
It is volume

- *SI unit o*
- Stress c
- Stress ch
- Stress ch

STRAIN

Str

- Strain is dimension
- *It is dimen*
- Strain due Tensile stra



Do you know?

The crystal structure is

- *B.C.C* *Body centered cube*
- *F.C.C* *Face centered cube*

A unit cell of B.C.C contains 9 atoms while a unit cell of F.C.C contains 14 atoms.

DEFORMATION IN SOLIDS

- The length of the strings will increase under the action of applied force.
- Greater the applied force, larger will be the increase in length.
- Atoms are held about their equilibrium position.
- The ability of the body to return to its original shape is called elasticity.

STRESS

It is the force applied on unit area to produce any change in shape, volume and length of the body.

Stress (б) = Force (F)/Area(A)

- *SI unit of stress is Newton per* ***square meter*** *(Nm^{-2}).*
- Stress changes length called ***tensile stress***
- Stress changes volume called ***compressional stress.***
- Stress changes shape called ***shear stress.***

STRAIN

Strain is a measure of deformation of solid

- Strain is defined as the ratio of change in dimension to the original dimension.
- *It is dimensionless* ***and has*** *no unit.*
- Strain due to tensile stress is called ***tensile strain.***

  Tensile strain = $\Delta L/L$

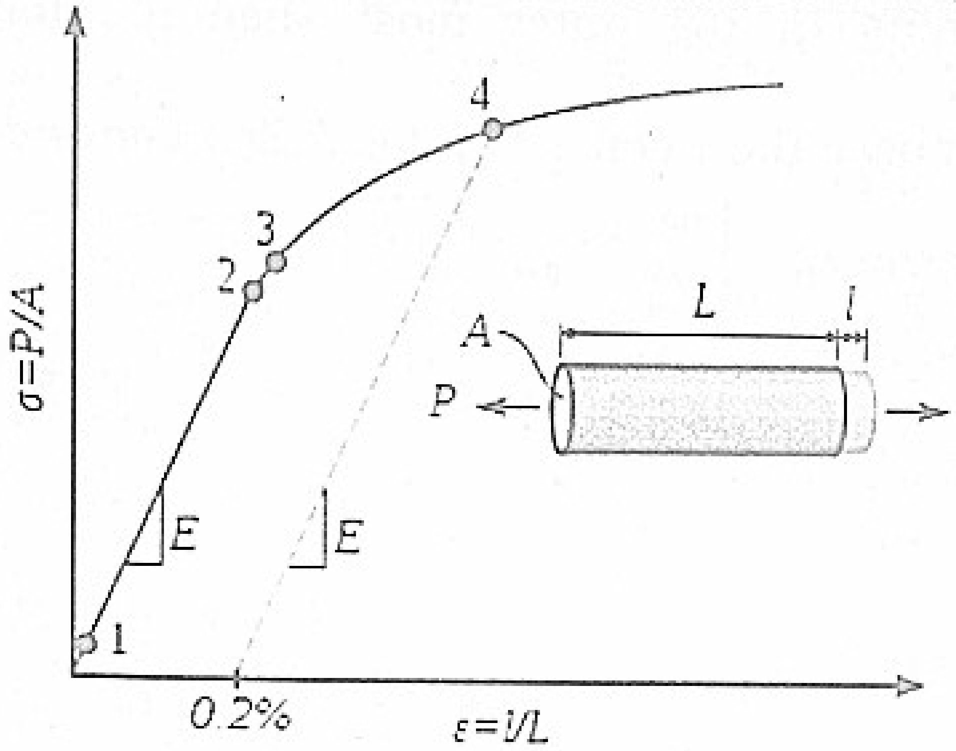
- Strain due to volumetric stress is called volumetric strain
  Volumetric strain = $\Delta V/V$
- When opposite faces of rigid cube are subjected to shear stress, then shear strain produced is given by
  $\gamma = \Delta a/a = \tan\theta \cong \theta$
  However, for small values of angle θ, measure in radian, $\tan\theta = \theta$, so that
  $\gamma = \theta$

ELASTIC CONSTANT

- The ratio of stress and strain is called ***modulus of elasticity.***
  $$\text{Modulus of Elasticity} = \text{Stress/Strain}$$
- It is dimensional quantity and its unit is **Nm^{-2} or Pascal.**
- The ratio of tensile stress and tensile strain is called ***Young's modulus.***
  $$Y = (F/A)/(\Delta\ell/\ell)$$
- The ratio of volumetric stress to volumetric strain is called ***Bulk modulus.***
  $$K = (F/A)/(\Delta V/V)$$
- The ratio of shear stress to shear strain is called ***shear modulus.***
  $$G = (F/A)/\tan\theta$$

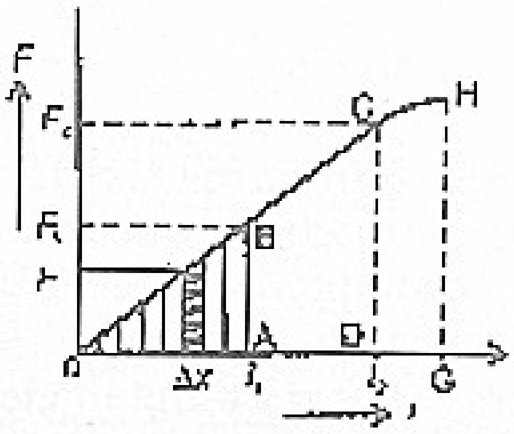
ELASTIC LIMIT AND YEILD STRENGTH

- The greatest stress that a material can endure without losing straight line proportionality between stress and strain is called proportionality limit.
- A material can endure in permanent change in shape or dimensions within certain limits called ***elastic limit* (σ_e).**
- Temporary deformation is called ***elastic deformation.***
- The specimen that does not change shape or dimension after the stress is removed, is **called *plastic.***
- The maximum stress that a material can withstand is called *ultimate tensile strength or ultimate tensile stress (σ_m).*
- Beyond ultimate tensile stress the material breaks is called *fracture* ***stress (σ_f).***
- Substances which undergo plastic deformation until they break, are called *ductile substance* e.g. Pb, Cu, wrought iron etc.
- Substances which break just after the elastic limit is reached are called *brittle substances* **e.g. glass and high carbon steel etc.**



STRAIN ENERGY IN DEFORMED MATERIALS

- Extension is directly proportional to force
- Work done = Area of triangle
  $= ½(\text{Base})(\text{Height})$
  $= 1/2\ell_1 x F_1$
- The gain in P.E of the molecules is due to their displacement from their mean position.



- Work can be expressed in term of modulus elasticity.

$$E = б / \varepsilon = (F_1/A) x (\ell/L)$$
$$E = (F_1/A) x L/\ell_1$$
$$F_1 = EAx\ell_1/L$$
$$W = ½[EAx\ell_1{}^2/L]$$

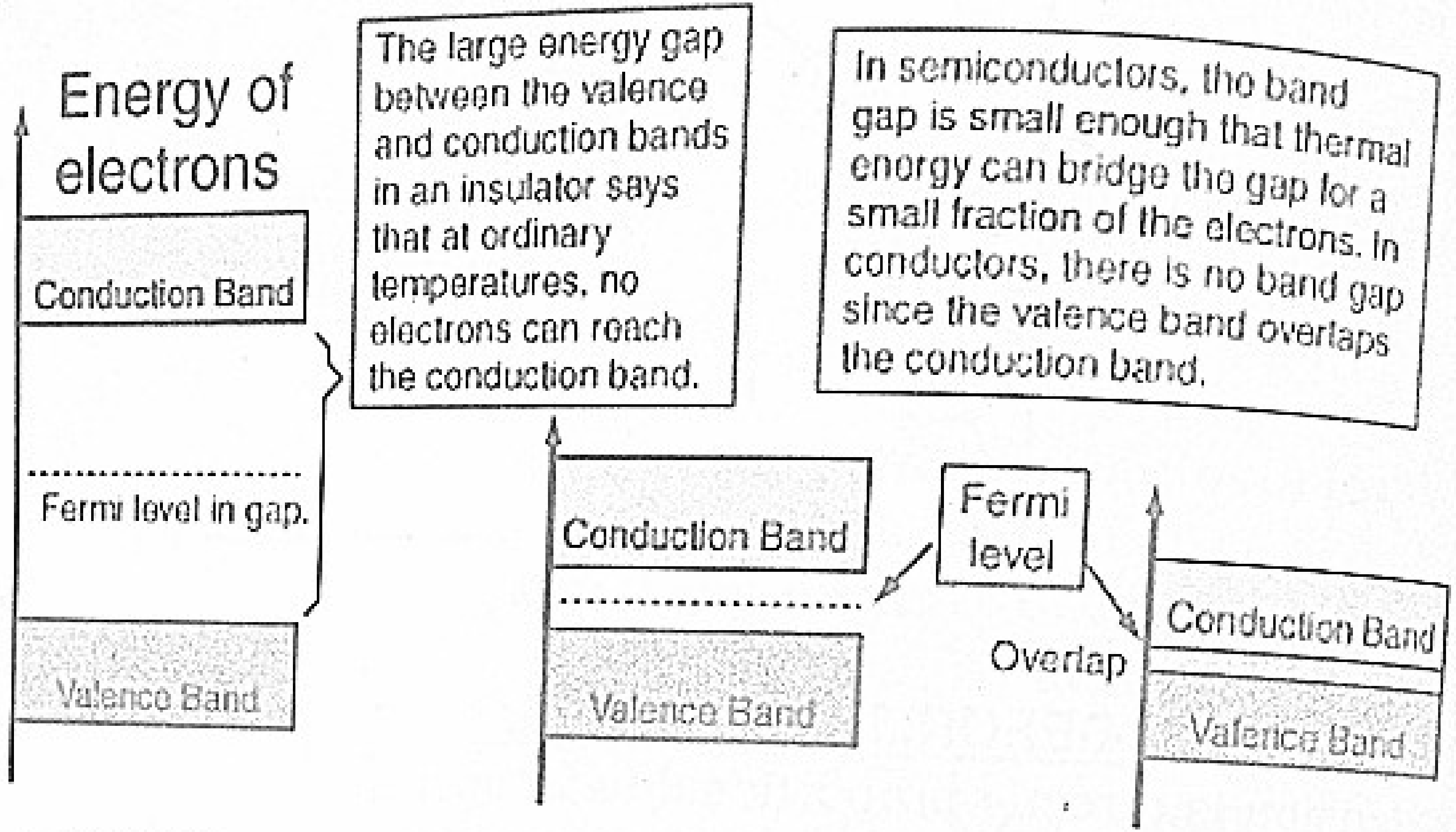
ELECTRIC PROPERTIES OF SOLIDS

- The electrical behavior of various materials is different.
- *Conductors have high conductivity of* $10^7 (\Omega m)^{-1}$
- *Insulators have low conductivity at* 10^{-10} *to* $10^{-20} (\Omega m)^{-1}$.
- *Semiconductors have intermediate conductivity from* 10^{-6} *to* $10^{-4} (\Omega m)^{-1}$.
- Bohr's theory cannot explain conductivity.

ENERGY BAND THEORY

- Electrons of an isolated atom are bound to the nucleus.
- Number of atoms are brought close together to form solid.
- An energy state, which cannot be occupied, is ***forbidden energy.***

- The electrons in the outer most shell of atom are called ***valence electrons.***
- The band above the valence band is called **conduction band.**



The large energy gap between the valence and conduction bands in an insulator says that at ordinary temperatures, no electrons can reach the conduction band.

In semiconductors, the band gap is small enough that thermal energy can bridge the gap for a small fraction of the electrons. In conductors, there is no band gap since the valence band overlaps the conduction band.

a. Insulator b. Semiconductor c. Conductor

- *Band theory of solid* says that electrons are present in different energy levels.
- Band theory arises as solution of **Schrödinger's wave equation** in wave mechanics.
- *Band is a set of sub-energy shells.*
- *Types of bands*
  1- Core band: **It accommodates tightly bound electron.**
  2- Valence band: It accommodates **outer most electrons.**
  3- Conduction band: It accommodates **electrons that conduct heat and electricity.**
- *Fermi Level:* It is an energy that pertains to electrons in a semiconductors
- *Energy gap* is a difference of energy between upper surface of valance band and lower surface of conduction band.
  Wider the energy gap, smaller is electrical conductivity.
- *Status of Energy Bands in Materials*

Description	***Core band***	***Valence band***	***Conduction band***
Conductors	*Completely filled*	*Overlap*	
Insulators	*Completely filled*	*Completely filled*	*empty*
Semi-conductors	*Completely filled*	*Partially filled*	*Partially filled*

- *Relationship of Energy Gap & Resistivity in Materials*

Description	***Energy Gap***	***Resistivity (Ω-m)***
Conductors	*Very narrow*	10^{-4}
Insulators	*Very wide*	10^{8}
Semi-conductors	*Moderate*	10^{-2} — 10^{2}

CONDUCTION IN SEMI-CONDUCTORS

- All semi-conductors are tetravalent.

- *Rise in temperature of semi-conductor increases its conductance and decreases its resistance.*
- Both electrons and holes are responsible for electrical conduction in **semi-conductors.**
- *Holes are not counter part of electrons* because they have no mass.
- Holes are vacant places **bearing positive** charge equal to that of electron and wait for electrons to fill in.
- When semi-conductor is subjected to potential difference, electron-hole pairs are produced due to break down of **covalent bond.** Free electrons and holes, both produce electric current in a semi conductor (it can also be done by heat).
- *Electrons are more* ***mobile than holes.***
- The conduction due to pair generation is called ***intrinsic conduction.***
- *Intrinsic conduction level may rise to double for every 10C° rise in temp.*

Types of Semi-conductors

- Intrinsic semi-conductors are Si and Ge.
- We can get extrinsic (n-type and p-type) semi-conductors by doping intrinsic semi-conductor with **specific impurities.**
- The impurities are added at the rate of one atom of doping element to10^5 to 10^8 atoms of semi-conductor.
- *Differences Between n-type & p-type Semi-conductors*

Particulars	*p-type*	*n-type*
Impurity present	*Trivalent or Acceptor*	*Pentavalent or Donor*
Action of Impurity	*Generate one hole per atom*	*Create one electron per atom*
Examples of Impurities	*B, Ga and In*	*P, As, Bi*
Minority Carriers	*Electrons*	*Holes*
Majority Carriers	*Holes*	*Electrons*

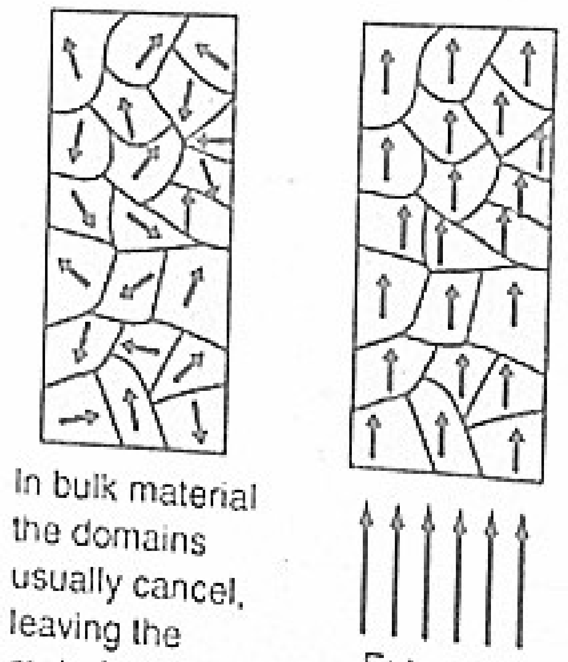
SUPER CONDUCTORS

- Temperature at which material losses its resistivity and becomes super conductor is called ***critical temperature.***
- The first super conductor was discovered in 1911.
- Critical temperature of Al(T_c=1.18K), tin (T_c=3.72K), lead (T_c=7.2K) & Hg(T_c=4.2K).
- Complex crystalline structure known as yattrium barium copper oxide ($YBa_2Cu_3O_7$) is super conductor at 163K i.e. at −110°C
- Any superconductor with a critical temperature above 77 k, the boilig point of liquid nitrogen, is referred as a high temperature superconductor.
- *Uses*
  - ✓ Magnetic resonance **imaging (MRI)**
  - ✓ Magnetic **Levitation trains**
  - ✓ Powerful but **small electric motors**
  - ✓ Faster computer chips
  - ✓ Concentrating U^{235} gas in centrifuge system.

Chapter 17 Physics of Solids

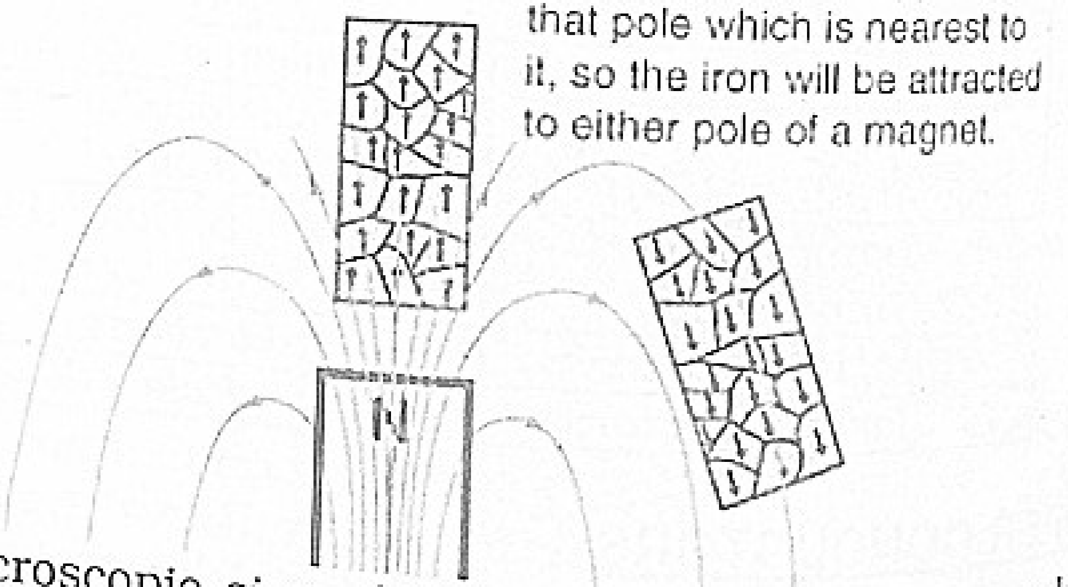
MAGNETIC PROPERTIES OF SOLIDS

- An atom in which there is a resultant magnetic field, behave like a tiny magnetic is called as ***magnetic dipole.***
- The orbits and the spin axes of electrons in an atom are so orientated that their fields support each other and atom behaves like a tiny magnet. Substances with such atoms are called ***paramagnetic substances.*** eg **aluminum platinum crown glass etc.**
- If there is no resultant field as the magnetic fields produced by both orbital and spin motion of electrons might add up to zero, the substances are called ***diamagnetic substances.*** e.g. water, copper, bismuth and antimony.
- There are some substances in which the atoms co-operate with each other in such a way so as to exhibit a strong magnetic effect. They are called ***ferromagnetic substances.*** e.g. Fe, Co, Ni, chromium dioxide, and alnico
- In ferromagnetic substances there are small regions called '***domains***'
- Each domain behaves as a small magnet with its own **North and South** Pole.



In bulk material the domains usually cancel, leaving the material unmagnetized.

Externally applied magnetic field.



Iron will become magnetized in the direction of any applied magnetic field. This magnetization will produce a magnetic pole in the iron opposite to that pole which is nearest to it, so the iron will be attracted to either pole of a magnet.

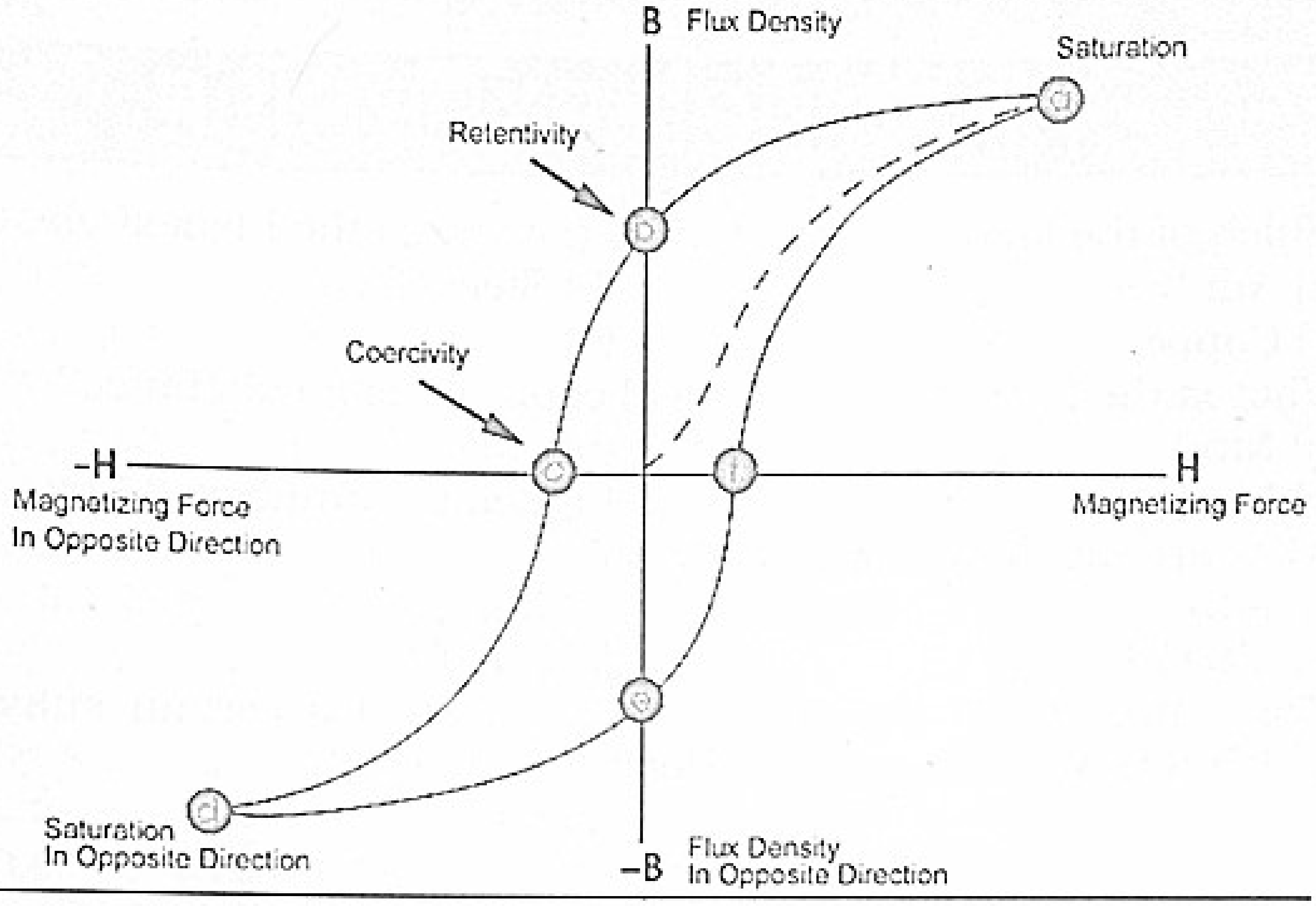
- The domains are of macroscopic size of the order of millimeters or less but large enough to contain 10^{12} to 10^{16} atoms.
- The combination for solenoid and a specimen of iron inside it makes a powerful magnet, called ***an electromagnet.***

Hysteresis

*The value of flux density for any value of current is always greater when the current is decreasing, than when it is **increasing** i.e.* ***magnetism*** *lags behind* ***the magnetizing current.***

Saturation

The magnetic flux density increases from zero and reaches a maximum value. At this stage, the material is said to be ***magnetically saturated.***



Remanence or Retantivity

When the current is reduced to zero, the material still remains strongly magnetized. It is due to the tendency of domains to stay partly in line, once they have ***been aligned.***

Coercivity

To demagnetize the material, the magnetizing current is reversed and increased to reduce the ***magnetization to zero;*** *this is known as coercive current.*

- Once the material is magnetized, its magnetization curve never passes through the **origin.**
- The Coercivity of steel is more than iron, so it requires more current to demagnetize.

Area of loop

- The area of Hysteresis loop is a measure of the energy needed to magnetize and demagnetize the specimen during each cycle. This is the energy required to do work against internal friction of domains. This work is done against friction, is dissipated as heat. It is called ***Hysteresis loss.***
- A material with high retentively and large coercive force, would be most suitable to make a permanent magnet.

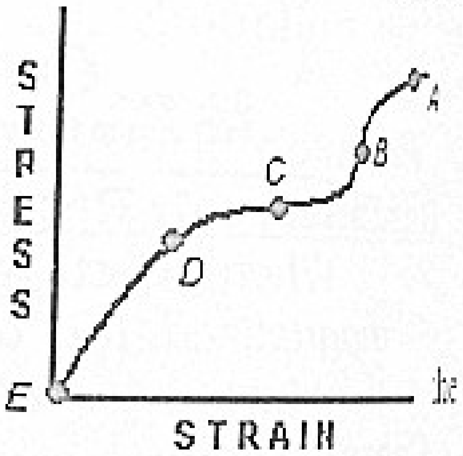
PRACTICE EXERCISE

(1) Which of the following substances possesses the highest elasticity?
(a) Rubber
(b) Steel Glass
(c) Copper
(d)

(2) What is the SI unit of modulus of elasticity of a substance?
(a) Nm^{-2}
(b) Jm^{-2}
(c) Nm^{-1}
(d) Being a number, it has no unit.

(3) What are the dimensions of stress?
(a) MLT^{-2}
(b) $ML^{-2}T^{-1}$
(c) $ML^{-1}T^{-2}$
(d) $ML^{0}T^{-1}$

(4) The figure shows the stress-strain graph of a certain substance. Over which region of the graph is Hook's law obeyed?



(a) AB
(b(BC
(c) CD
(d) ED

(5) Which one of the following physical quantit dimensions of force per unit area?
(a) Stress
(b) Strain
(c) Young's modulus
(d) Pressure

(6) If a wire is stretched to double of its length then the strain will be
(a) zero
(b) 1
(c) ½
(d) Double

(7) A wire of length L is stretched by a length ℓ when a force F is applied at one end. If the elastic limit is not exceeded, the amount of energy stored in the wire is ________
(a) Fℓ
(b) ½ (Fℓ)
(c) $F\ell^2/L$
(d) $\frac{1}{2}\frac{F\ell^2}{L}$

(8) When a force is applied at one end of an elastic wire, it produces a strain ϵ in the wire. If y is the young's modulus of the material of the wire, the amount of energy stored per unit volume of the wire is given by______
(a) Yϵ
(b) ½ Yϵ
(c) $Y\epsilon^2$
(d) ½ $Y\epsilon^2$

(9) A wire, suspended vertically from one end, is stretched by attaching a weight of 20 N to the lower end. The weight stretches the wire by 1mm. How much energy is gained by the wire?
(a) 0.01J
(b) 0.02J
(c) 0.04J
(d) 1.0J

(10) The area method to find energy stored in deformed material is valid for
(a) Elastic region
(b) Non-elastic region
(c) Both a & b
(d) Elastic for small force

(11) N-type crystals have
(a) Positive charge
(b) Negative charge
(c) neutral
(d) none of these

(12) The resistivity of semiconductor is of the order of NOT PER (2LV5)

(a) 10^{-6} to 10^{-4} Ωm (b) 10^{4} to 10^{6} Ωm

(c) 10^{-10} to 10^{-20} Ωm (d) 10^{7} Ωm

(13) Materials that undergo plastic deformation before breaking are called____

(a) Brittle (b) Ductile

(c) Amorphous (d) Polymers

(14) How does the Young's modulus vary with the rise in temperature

(a) decreases (b) increases

(c) remain same (d) none of these

$Y = F/A \times L/\Delta L$

(15) At 0 K a piece of Si has

Conduction band	Valence band
(a) Filled	Filled
(b)Empty	Filled
(c) Empty	Empty
(d) Filed	Empty

(16) Which of the following group represent doner atoms

(a) Indium, aluminum, phosphorous

(b) Aluminum, indium, gallium

(c) Phosphorous, antimony, arsenic 5th grp. Pentavalent

(d) None

(17) Any alteration produced in shapes, length or volume when a body is subjected to some external force is called ___________

(a) Stiffness (b) Toughness

(c) Extension (d) Deformation

(18) The energy band occupied by the valence electrons is called ___________

(a) Energy state (b) Valence band

(c) –ve energy state (d) conduction band

(19) The curie temperature is that at which ___________

(a) Semi-conductor becomes conductors

(b) Ferromagnetic becomes paramagnetic

(c) Paramagnetic becomes diamagnetic

(d) Metals become super conductor

(20) A ferromagnet will become fully magnetized at ___________

(a) High voltage A.C

(b) Low voltage A.C

(c) Alternating current at its peak value

(d) D.C current at peak value

(21) Which of the following produce magnetic field

(a) Orbital motion of electron (b) Spin motion of electron

(c) Spin motion of nucleus (d) All

(22) Materials in which valence electrons are tightly bound to their atoms at low temperature are called ___________

(a) Semi conductor (b) Super conductors

(c) Insulators (d) Conductor

(23) The modulus of eleasticity of liquids is

(a) 1 (b) zero

(c) infinity (d) none of these

(24) The young's modulus of wire of length L and radius r is Y. If the length is reduced to L/2 and radius to r/2, its Young's modulus will be
(a) Y/2
(b) 2Y
[✓ (c) Y]
(d) 4Y

(25) Which of the following is not true for a crystalline substance?
[✓ (a) short range order]
(b) flat surfaces
(c) Sharp melting point
(d) all

(26) A hole in a p – type semiconductor is
(a) an excess electron
[✓ (b) a missing electron]
(c) a missing atom
(d) a donor level

(27) The band theory of solids explains satisfactorily the nature of ______
(a) Electrical insulators alone
(b) Electrical conductors alone
(c) Electrical semi conductors alone
[✓ (d) All of the above]

(28) A vacant or partially filled band is called ______
[✓ (a) Conduction band]
(b) Valence band
(c) Forbidden band
(d) Empty band

(29) A completely filled band is called ______
(a) Conduction band
(b) Valence band
(c) Forbidden band
[✓ (d) Core band]

(30) The electrons in conduction band are free to ______
(a) Transport vibrations
(b) Transport signals
[✓ (c) Transport charge]
(d) Transport impulses

(31) Which one has the greatest energy gap?
(a) Semi conductor
(b) Conductor
(c) Metals
(d) Non metals

(32) With increase in temperature the electrical conductivity of intrinsic semi conductor ______
(a) Decreases
(b) Increases
(c) Remains same
(d) First increases then decreases

(33) Holes can exist in ______
(a) Conductors
(b) Insulators
(c) Semi conductors
(d) All of the above

(34) On the basis of band theory of solids, the semiconductors at room temperature have ______
(a) A partly filled valence band and totally empty conduction band
(b) A completely filled valence band a totally empty conduction band and
(c) a very wide forbidden band
[✓ (d) A partially filled valence band, a partially filled conduction band and a narrow forbidden band]
(e) A partly filled valence band, a totally empty conduction band and a wide forbidden band

(35) In a semiconductors, the charge carriers are ______
(a) Holes only
(b) Electrons only
(c) Electron and holes both
(d) All of the above

(36) The net charge on n-type material is ______
(a) Positive
(b) Negative
(c) Both positive and negative
(d) Neutral

(37) Very weak magnetic fields are detected by ______
(a) Squids
[✓ (b) Magnetic resonance imaging (MRI)]
(c) Magnetometer
(d) Oscilloscope

(38) Energy needed to magnetize and demagnetize is represented by________

(a) Hysteresis curve [✓ (b) Hysteresis loop area]

(c) Hysteresis loop (d) Straight line

(39) In simple cube, one atom or molecule lies at its

(a) force corners (b) nine corners

[✓ (c) eight corners] (d) six corners

(40) Many of the semi conductors are crystals of the type

[✓ (a) face centered cube] (b) body centered cube

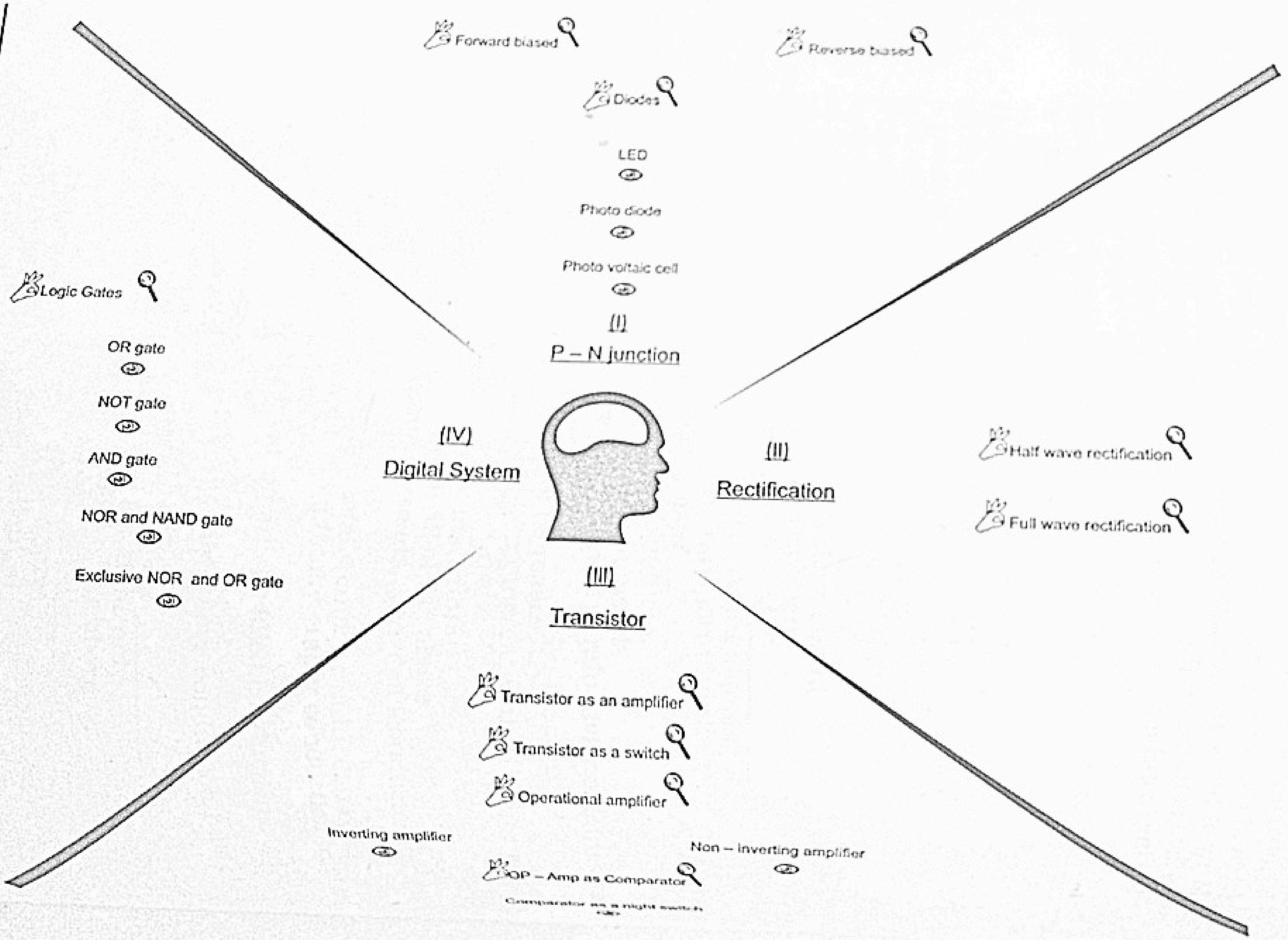
(c) simple cube (d) all of the above

$Y = F/A \times \frac{[illegible]}{[illegible]} = \frac{F}{A} \times \frac{L \times r}{\ell \times R}$

$Y' = \frac{F}{A} \times L$

Chapter 18

ELECTRONICS

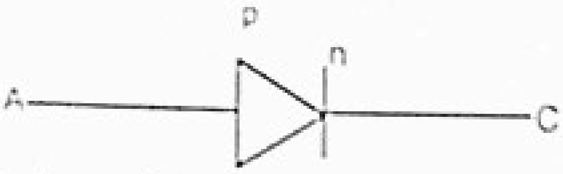


Chapter 18

Electronics

p-n JUNCTION AND ITS CHARACTERISTICS

A p-n junction is formed when a crystal of ***germanium*** *or* ***silicon*** *is grown in such a way that if one half is doped with a* ***trivalent impurity*** *and the other half with* ***pentavalent impurity***



- Its n-region contains free electrons as majority charge carriers and p-region contains holes as majority charge carriers.
- In N-region the minority current carriers are holes while electrons are minority current carriers in case of P-region.
- Just after the formation of the junction, the free electrons in the n-region because of their random motion diffuse into p-region. As a result, a charge less region is formed around the junction in which charge carriers are not present. This region is known as *depletion region.*

Do you know?

An extrinsic semi conductor i.e. a semi conductor after doping still remains electrically neutral whether it is p-type or n-type

FORWARD BIASED p-n JUNCTION

When an ***external*** *potential difference is applied across a p-n junction such that p-side is positive and n-side is negative.*

- The external potential difference supplies energy to free electrons in the n-region and to holes in p-region. When this energy is sufficient to overcome the **potential barrier**, a current of the order of a few miliamperes begins to flow across the p-n junction. In this state, p-n junction is said to be ***forward biased.***
- If for ward bias voltage is increased by ΔV_f, the current increases by ΔI_f. The ratio $\Delta V_f/\Delta I_f$ is known as ***forward resistance*** *of the p-n junction.* i.e.

$$r_f = \frac{\Delta V_f}{\Delta I_f}$$

For your information

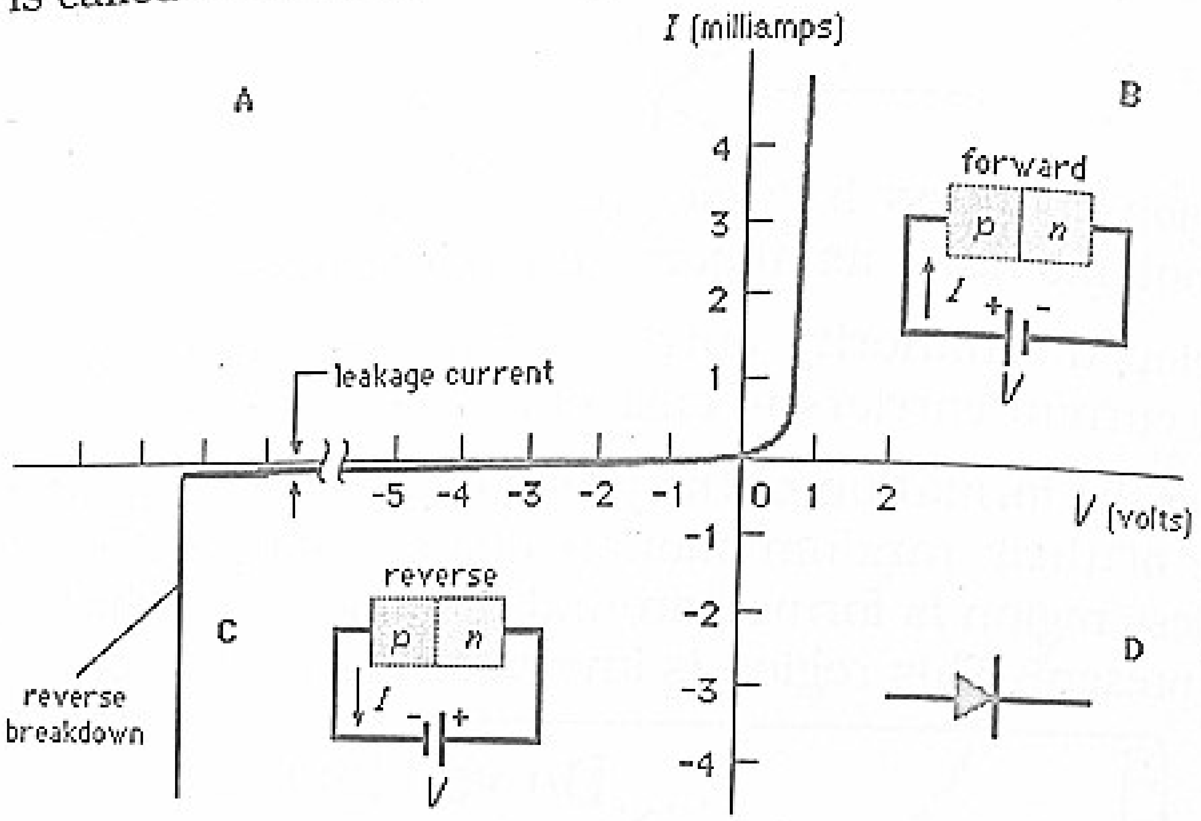
The forward biased barrier potential for silicon is 0.7v while for Germinium is 0.4v.

REVERSE BIASED p-n JUNCTION

When the external source of voltage is applied across a p-n junction such that its positive terminal is connected to n-region and its negative terminal to p-region

- In reverse biased situation, no current flows due to the **majority charge carriers.** However a very small current, of the order of few micro amperes, flows across the junction due to flow of minority charge carriers, known as *reverse current or leakage current.*

- Leakage current increases with increase in temperature.
- At a certain high voltage the reverse current increases sharply. This voltage is called break down voltage.



For your information

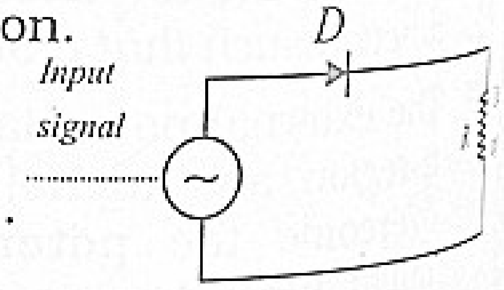
The leakage current for Ge is in amperes while for silicon it is in microamperes

RECTIFICATION

Conversion of alternating current into direct current is called rectification.

- There are two very common types of rectification.

Half-wave rectification (HWR)



- One diode is used.
- For upper half or lower half is rectified.
- Can be used for charging battery.

Draw Backs

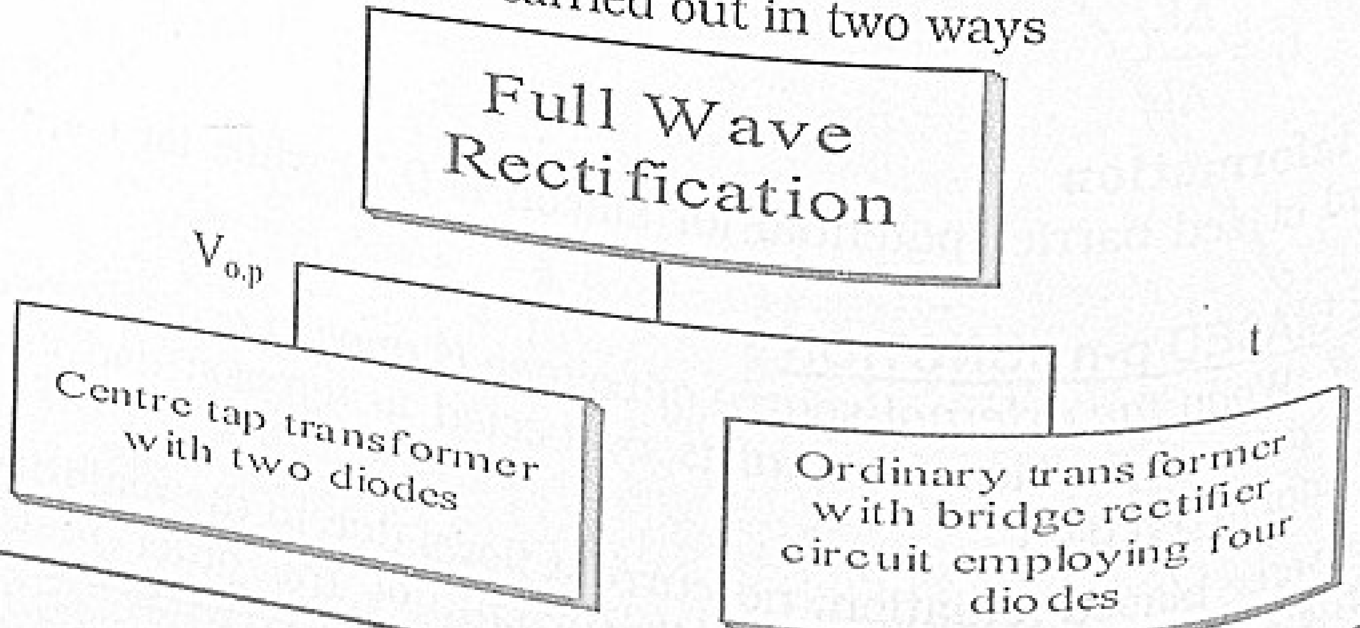
- More pulsations in the output wave form.
- Average value of the out put DC signal drops.

V_{in}

Full wave Rectification (FWR)

t

Can be carried out in two ways


Full Wave Rectification
V o.p
t
Centre tap transformer with two diodes
Ordinary trans former with bridge rectifier circuit employing four dio des

---

Bridge Re ifier

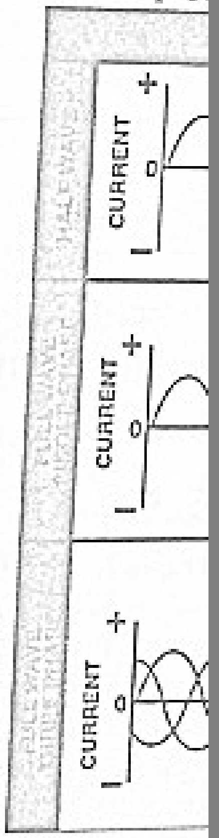
- F ur c
- T o d while cycle.

Summary

If input wave ha

O ~ T/2 D1 &

T/2 ~ T D1 &



Advantages

- Very inexp
- Average val
- Lesser puls

The freq

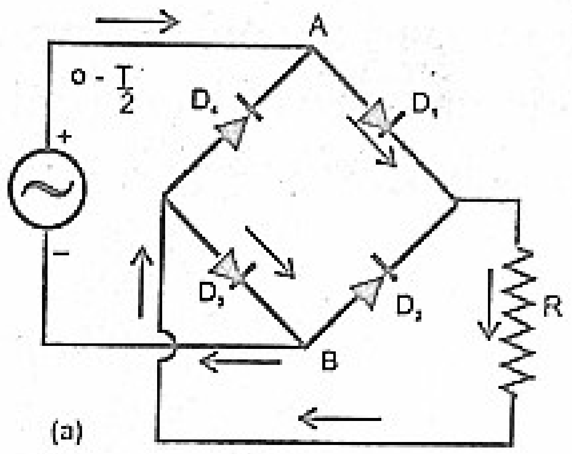
SPECIALLY DESIGN

LIGHT EMITTING

- Light emitting d as gallium arse

Bridge Rectifier

- Four diodes are used.
- Two diodes remains ON (FWD Biased) in each half of the input cycle while other two remains off (Reverse Biased) in the same half o the cycle.

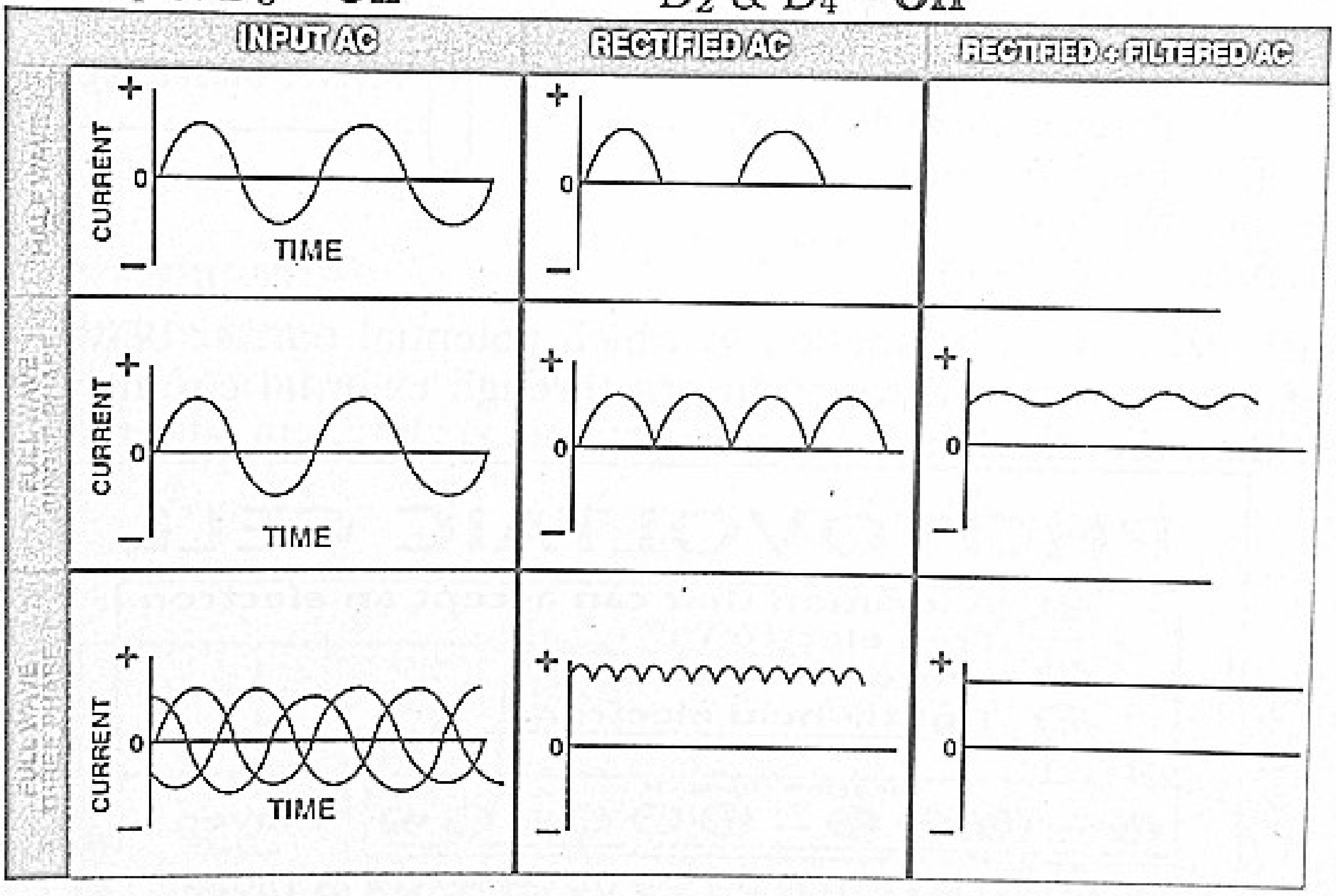


(a)

Summary

If input wave has "T" Time period then

O ~ T/2 D₁ & D₃ – **Off** and D₂ & D₄ – **On**
T/2 ~ T D₁ & D₃ – **On** D₂ & D₄ – **Off**



Advantages

- Very inexpensive method of rectification.
- Average values do not drop significantly.
- Lesser pulsations are there in the signal compared to HWR.

> **Do you know?**
>
> *The frequency of the FWR wave is two times the source frequency*

SPECIALLY DESIGNED p-n JUNCTIONS

LIGHT EMITTING DIODE

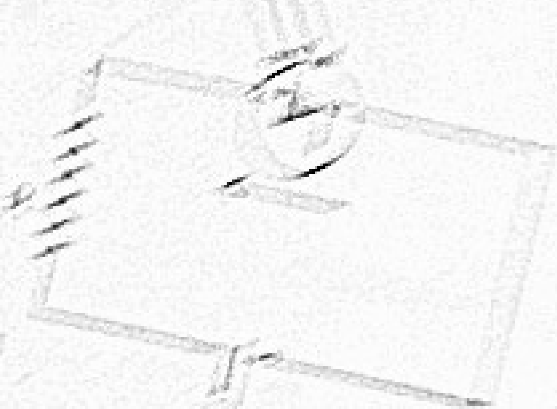
- Light emitting diodes (LED) are made from special semi-conductors such as **gallium arsenide** and **gallium arsenide phosphide**.

(33)
(34)
(35)
(36)
(37)
(38)
(39)
(40)

- When an [illegible] a photon of [illegible]
- Convert Electric energy into light.

PHOTO DIODE

- Photo diode is used for [illegible]
- A photo diode can [illegible]
- Photo diode is [illegible]

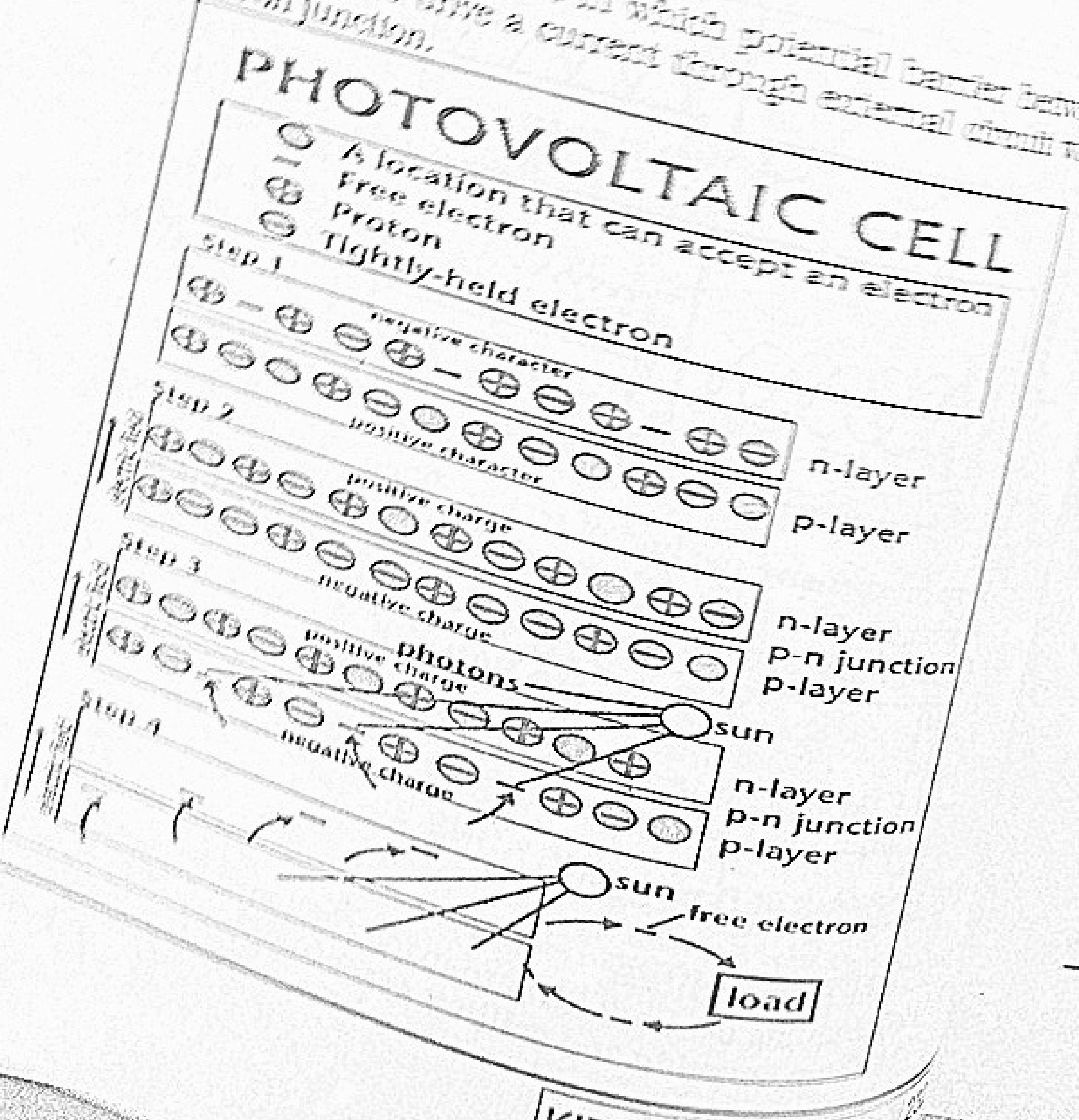


- **Applications**
  - (i) Detection of both visible and invisible spectrums
  - (ii) Automatic switching
  - (iii) Logic circuits.
  - (iv) Optical

Do you know
The photo diode is operated in reverse biased region.

PHOTOVOLTAIC CELL

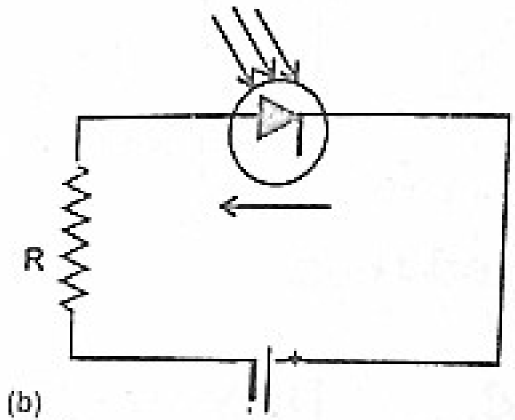
- Such cells are p-n junction in which potential barrier between p-n regions is used to drive a current through external circuit when light is incident on junction.



- When an electron combines with a hole during forward bias conducti a photon of **visible light is emitted..**
- Convert Electric energy in to light

PHOTO DIODE

- Photo diode is used for **detection of light.**
- A photo diode can turn its current **ON** and **OFF** in nano seconds.
- Photo diode is fastest photo detection device.



(b)

- ***Applications***
  - (i) Detection of both visible and invisible spectrums
  - (ii) Automatic switching.
  - (iii) Logic circuits.
  - (iv) Optical

Do you know?

The photo diode is operated in reverse biased region

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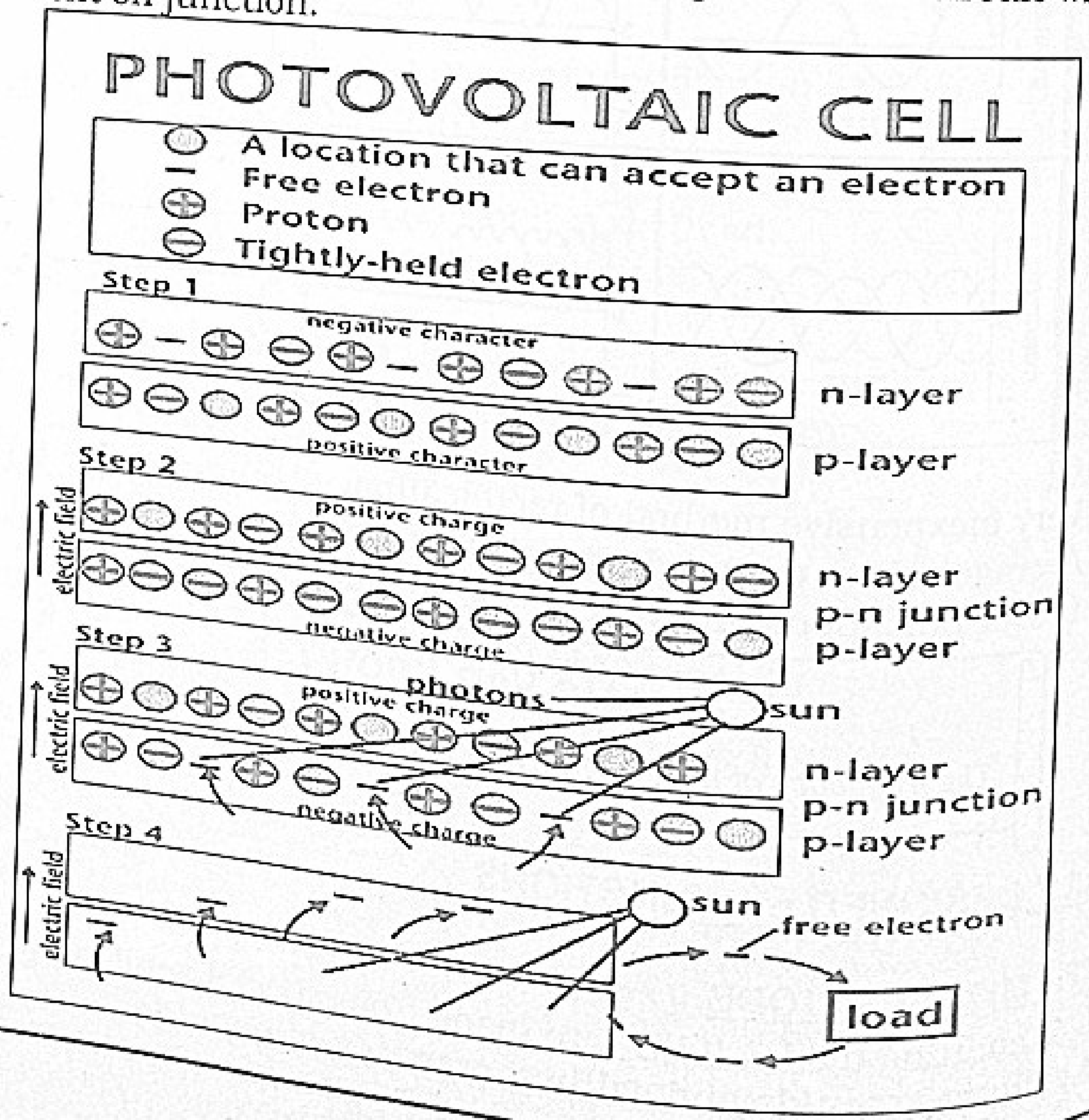
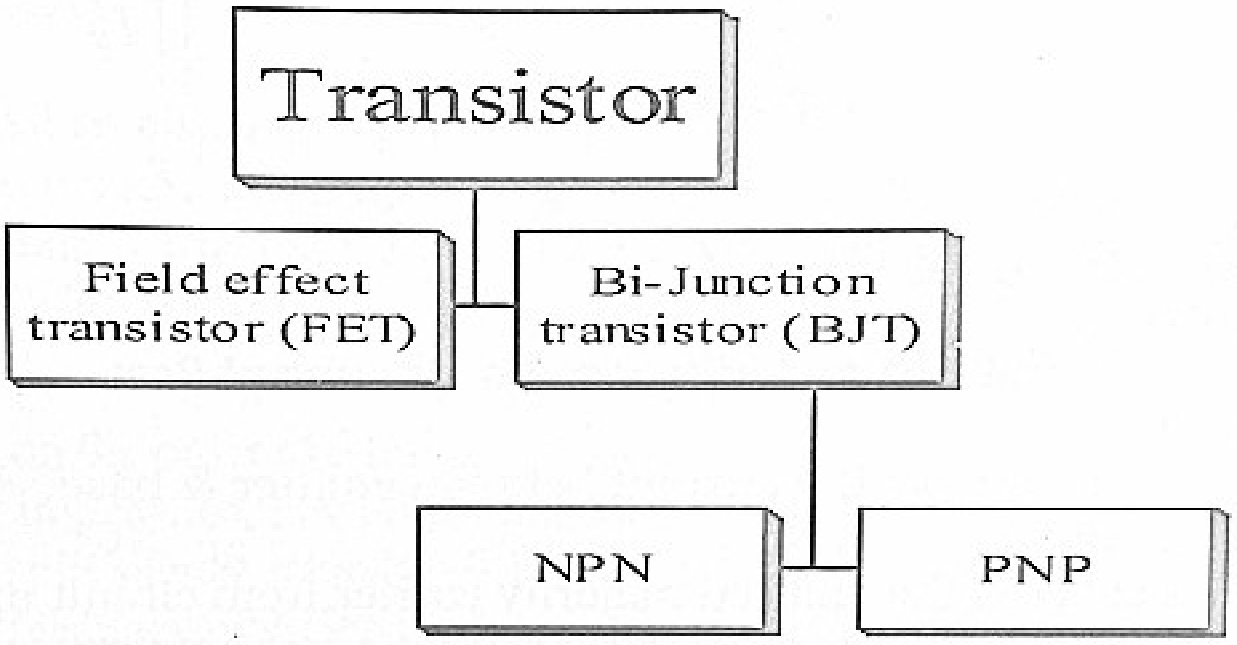


- The current is directly proportional to the intensity of light.
- In order to obtain greater power, series-parallel arrays of thousands of such cells are used forming ***photovoltaic panels*** and are commonly used in satellites and space stations.

TRANSISTORS

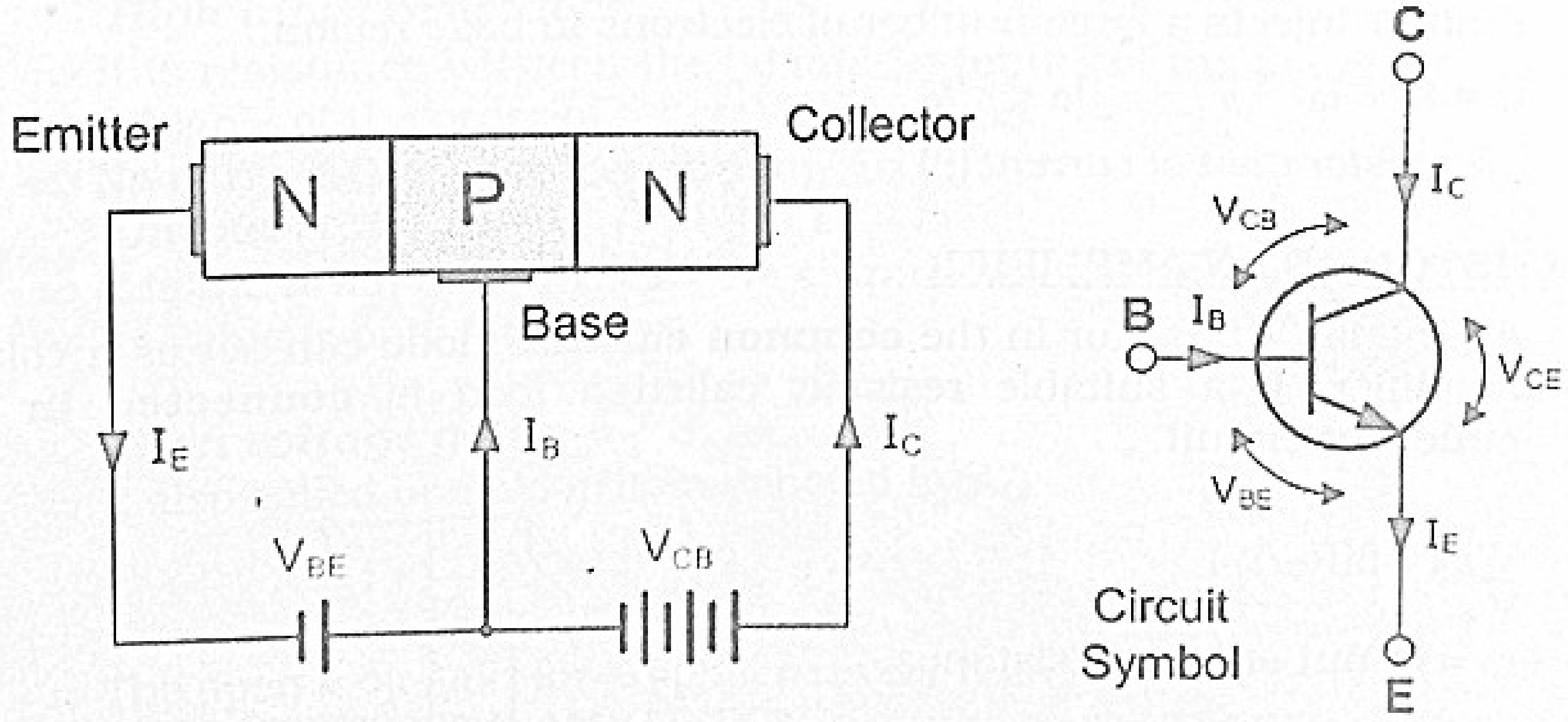
An active component of an electronic circuit consisting of a small block of semi-conducting material to which at least three electrical contacts are made.



TYPES OF TRANSISTORS

n-p-n transistors

*A transistor in which **p-type** material is **sandwiched** between two n-type materials is known as n-p-n transistor.*



p-n-p transistor

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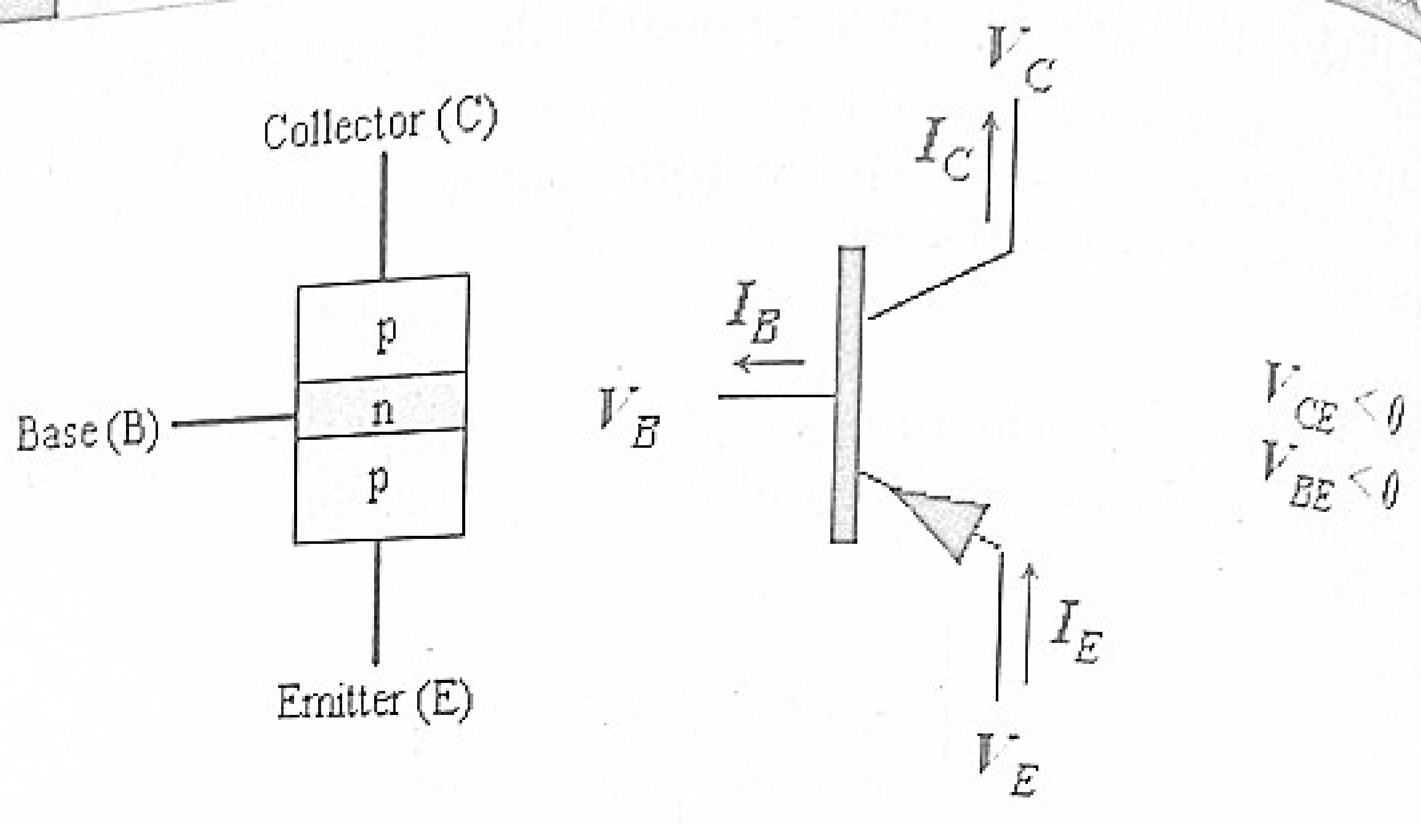


TERMINALS OF TRANSISTORS

Emitter

It provides majority carriers for current flow

Base

It controls the current between emitter & base.

Collector

It collects the emitted majority carrier from circuit operation. *The emitter has greater concentration of impurity as compared to the collector. Collector is physically larger than emitter.*

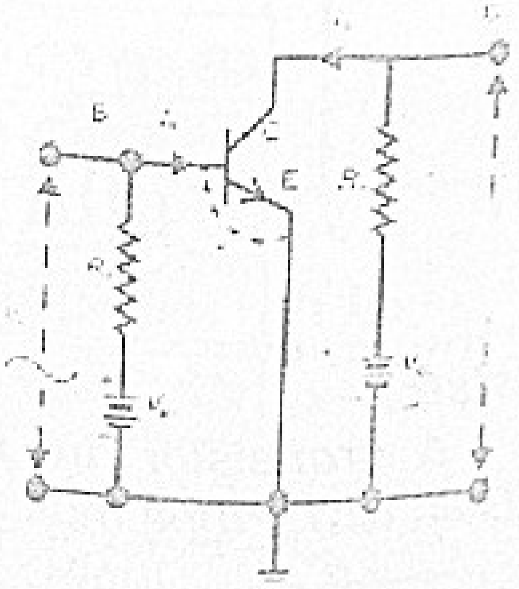
CURRENT FLOW IN n-p-n TRANSISTOR

- Emitter base junction is forward biased.
- Emitter injects a large number of electrons in base region.
- $I_E = I_C + I_B$, $I_B << I_c$
- *Transistor gain of current* $(\beta) = \dfrac{I_C}{I_B}$

TRANSISTOR AS AN AMPLIFIER

- A junction transistor in the **common emitter** mode can act as a voltage amplifier, if a suitable resistor, called a *load* is **connected** in the **collector** circuit.
- $\dfrac{V_{out}}{V_{in}} = \beta(R_C/r_{ie})$

  r_{ie} = in put emitter resistance



- The ratio of $\dfrac{V_{out}}{V_{in}}$ is called ***voltage gain of the amplifier.***

TRANSISTOR AS A

- Transistors a
- In order to t control termi
- An electroni switches, whi

OPERATIONAL AM

- An operation **electronicall**

The term operational a amplifiers with two inp typified by the famous are:

- High gain, on th
- High input impe
- Used with split
- Used with feedb feedback netwo

CHARACTERISTICS

High input re

⇒ It is resistance very high – of the

⇒ No current flows

Output resisto

⇒ It is the resistan

⇒ Its value is only

High voltage g

⇒ It also called op

$V_o = 1 + \frac{V}{V}$

⇒ The open loop ga

OP-AMP AS INVERTI

- The non-inverti
-
- No current flows rule.

$I_1 =$

TRANSISTOR AS A SWITCH

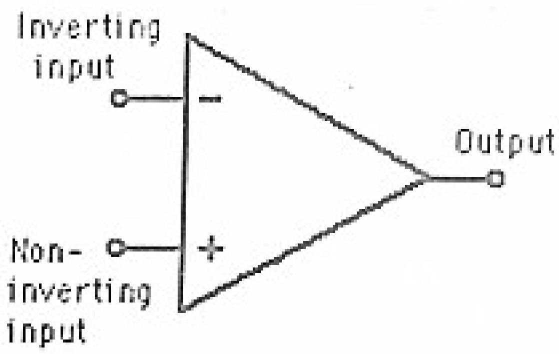
- Transistors are used as switches in many important electronic circuits.
- In order to turn on the switch, a large potential V_B is applied betwee control terminals.
- An electronic computer is basically vast arrangement of electronic switches, which are made from **transistors**.

OPERATIONAL AMPLIFIER

- An operational amplifier is so called because it can perform **electronically**.

The term operational amplifier or "op-amp" refers to a class of high-gain DC coupled amplifiers with two inputs and a single output. The modern integrated circuit version is typified by the famous 741 op-amp. Some of the general characteristics of the IC version are:

- High gain, on the order of a million
- High input impedance, low output impedance
- Used with split supply, usually +/- 15V
- Used with feedback, with gain determined by the feedback network.



CHARACTERISTICS OF OPERATIONAL AMPLIFIER

High input resistance

⇒ It is resistance between the (+) and (−) inputs of the amplifier. Its value is very high – of the order of several mega ohms.

⇒ No current flows between two inputs.

Output resistance

⇒ It is the resistance between the output terminal and ground.

⇒ Its value is only few ohms

High voltage gain

⇒ It also called open loop gain denoted by A_{OL}

$$V_o = 1 + \frac{V_o}{V_i} \qquad A_{OL} = \frac{V_o}{V_i}$$

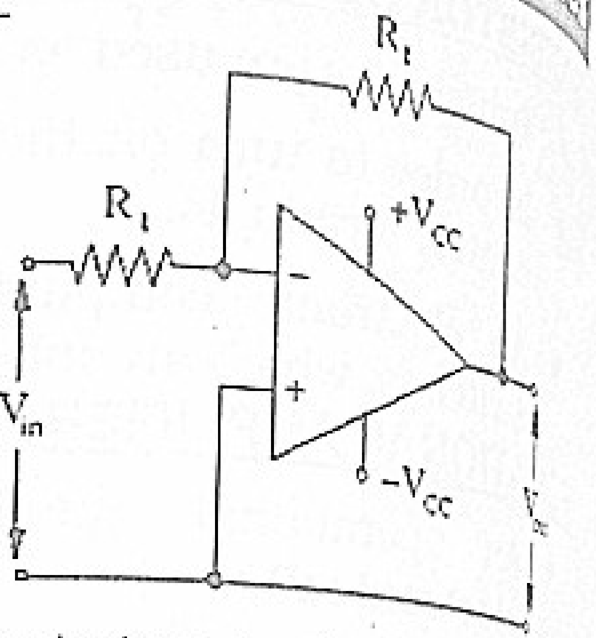
⇒ The open loop gain for amplifier is very high ~10^5.

OP-AMP AS INVERTING AMPLIFIER

- The non-inverting terminal (+) is grounded; its potential is zero
- $I_1 = V_i/R_1$ & $I_o = -V_o/R_2$
- No current flows between (+) and (-) terminals. Therefore, by Kirchhoff's rule.

$I_1 = I_2$

$$\frac{V_i}{R_1} = -\frac{V_o}{R_2} \qquad -\frac{R_2}{R_1} = \frac{V_o}{V_i}$$

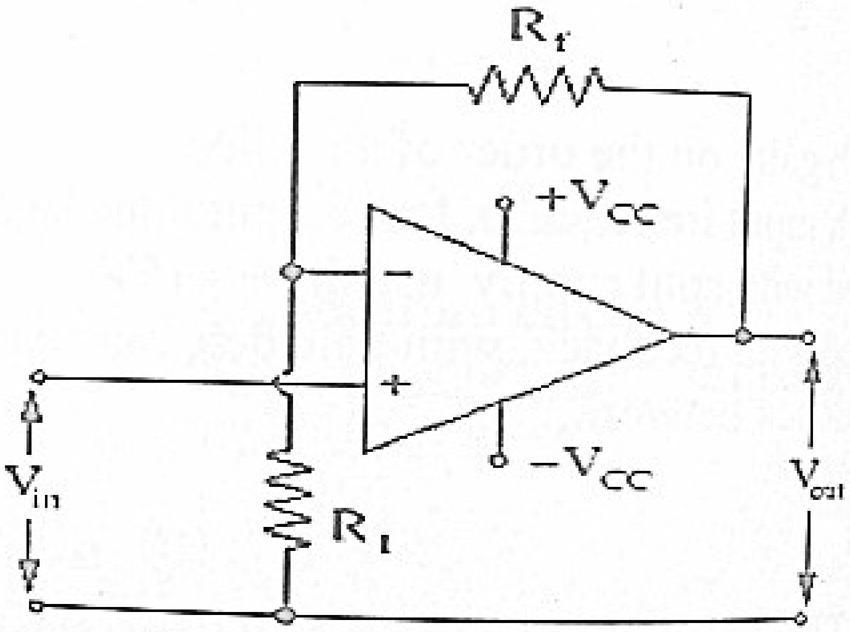


- Signal is inverted
- Gain is defined as the ratio of output voltage to input voltage. $G = -\frac{R_2}{R_1}$

OP-AMP AS NON-INVERTING AMPLIFIERS

- In this case the input signal V_i is applied at the non-inverting terminal (+).

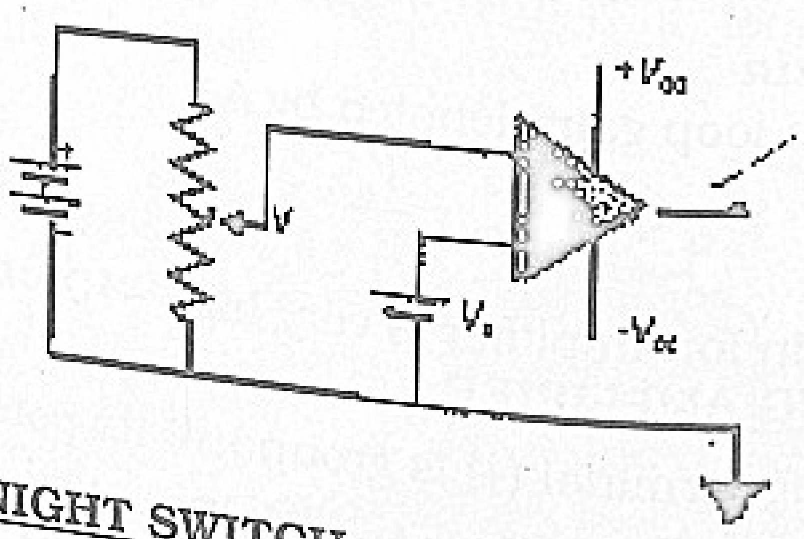
$$\text{Gain} = V_o = 1 + \frac{V_o}{V_i}$$



Gain only depends upon values of R_2 and R_1 and is independent the open loop gain of the OP-AMP.

OP-AMP AS A COMPARATOR

- OP-AMP usually requires two power supplies of equal voltage, but opposite polarity.
- Most OP-AMP operate with $V_{CC} = \pm 12V$ **supply.**



COMPARATOR AS A NIGHT SWITCH

- When intensity of light falls below a certain level, the streetlight **automatically switched** on. This can be accomplished by using OP-A as a comparator.

- $V_R = \frac{R_2}{R_1+R_2} \times V_{CC}$.
- *LDR is light dependent resistance.*
- $V' = \frac{R_3}{R_L+R_3} \times V_{CC}$.

V' provides the voltage to (–) input of OP-AMP.

At Day time

$V' > V_r$

and $V_o = -V_{cc}$

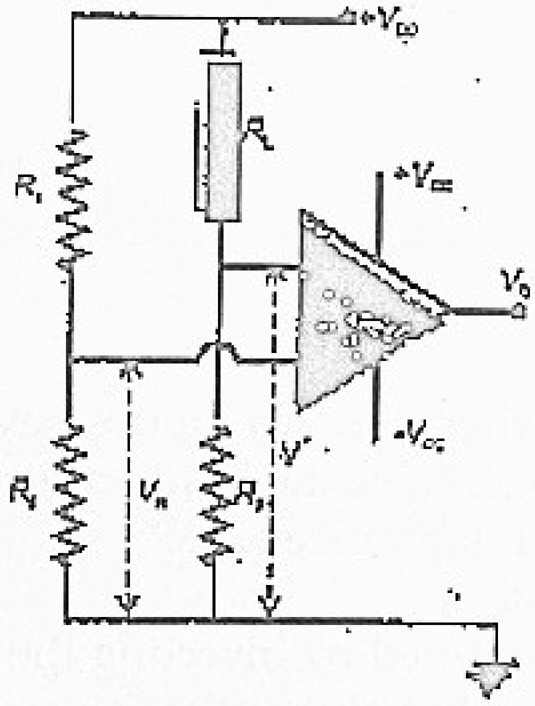
Light switched off

At Night

$V' < V_r$

$V_o = +V_{cc}$

Light switched on



DIGITAL SYSTEMS

A digital system deals with quantities or variables, which have only two ***discrete values or states.***

- In describing functions of digital systems, a closed switch will be shown as **1** and an open switch will be shown as **0**.

LOGIC GATES

The electronic circuits that implement the various logic operations are known as logic gates.

FUNDAMENTAL GATES

OR gate

⇒ It has two or more inputs and single output X.

⇒ The X will be zero when both inputs are zero.

⇒ Mathematically, $X = A + B$

AND gate

⇒It has two or more inputs and a single output.

⇒Its output X will be 1 when both inputs A and B are 1.

⇒Its output X will be zero when both inputs are zero.

⇒Mathematically, $X = A . B$

NOT gate

⇒It performs the operation of inversion or complementation so, it is also known as inverter.

⇒It changes 1 to 0 and 0 to 1.

⇒ Mathematically, $X = \overline{A}$

DERIVED LOGIC GATES

NOR gate

⇒In NOR gate the output of OR gate is inverted.

⇒Mathematically, $X = \overline{A + B}$

NAND gate

⇒In NAND gate the out put of an AND gate is inverted.

⇒The bubble in the symbol of NAND gate shows that the output of AND gate is inverted.

⇒Mathematically, $X = \overline{A . B}$

Exclusive OR gate (XOR)

⇒A logic circuit whose output signal is 1 when inputs are different is known as exclusive OR gate.

⇒$X = A.\overline{B} + \overline{A}.B$

⇒The value of X is 0 when the two inputs have the same values.

⇒It is 1 when the inputs have different values.

⇒XOR gate also called difference gate.

Exclusive-NOR gate (XNOR)

⇒The XNOR gate is obtained by inverting the output of a XOR gate.

⇒The bubble in its symbol shows that the output of XOR gate has been inverted.

⇒Its Boolean expression is

$$X = \overline{A.\overline{B} + \overline{A}.B}$$

⇒Its output is 1 when two inputs are identical and 0 when two inputs are different.

⇒It is also constructed by a combination of NOT, AND and NOR gates.

USES OF LOGIC GATES

- Logic gates are circuits in which transistors act as a light switches.
- Logic gates are used in **pocket calculators, digital watches computers, robots** and **industrial control system.**
- Logic gates are also used in **telecommunications. Application of gates**

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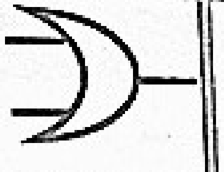
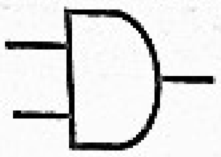
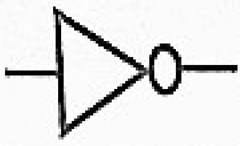
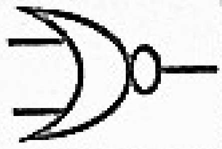
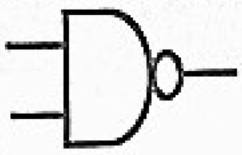
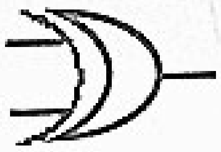
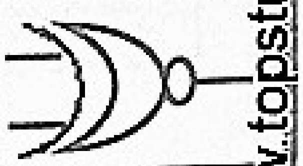
Input		*OR*	*AND*	*NOT*	*NOR*	*NAND*	*XOR*	*XNOR*
A	*B*							
		$X=A+B$	$X=A.B$	$X=\overline{A}$	$X=\overline{A+B}$	$X=\overline{A.B}$	$X=A\overline{B}+\overline{A}B$	$X=\overline{A\overline{B}+\overline{A}B}$
0	0	0	0	1	1	1	0	1
0	1	1	0	1	0	1	1	0
1	0	1	0	0	0	1	1	0
1	1	1	1	0	0	0	0	1

PRACTICE EXERCISE

30 min Time Yourself

(1) In p-type semiconductor the majority and minority charge carriers are
[✓ (a)holes and electrons]
(b)electrons and protons
(c)electrons and holes
(d)holes and protons

(2) Semi-conductors with donor atoms and free electrons belong to the type ______
[✓ (a)n]
(b)p
(c)mix
(d)any of above

(3) Diode can work as
(a)oscillator
(b)transformer
(c)generator
[✓ (d)rectifier]

(4) Acceptor and donor impurities donate______________
(a)n-carriers only
(b)p-carriers only
[✓ (c)p-carriers and n- carriers respectively]
(d)n-carriers and p-carriers respectively

(5) p-n junction when reversed biased acts as a ____________
(a)capacitor
[✓ (b)inductor]
(c)on switch
[✓ (d)off switch]

(6) In p-n-p transistor, the collector current is ____________
(a)equal to emitter current
[✓ (b)slightly less than emitter current]
(c)greater than emitter current
(d)any of above

(7) In n-p-n transistor, p works as __________
(a)collector
(b)emitter
[✓ (c)base]
(d)any of above

(8) The simplest type of rectification known as half wave rectification is obtained by __________
(a)using a transistor
(b)suppressing the harmonics in A.C voltage
[✓ (c)suppressing half wave of A.C supply by using diode]
(d)using a Coolidge tube

(9) Identify the correct statement about minority carriers-
[✓ (a)holes in n-type and free electrons in p-type]
(b)holes in n-type and p-type
(c)free electrons in n-type and holes in p-type ✗
(d)free electrons in n-type and p-type

(10) Depletion region of a junction is formed_______________
[✓ (a)during the manufacturing process]
(b)under forward bias
(c)under reverse bias
(d)when temperature varies

(11) The velocity of an oscillating charge as it moves to and fro along a wire is always_______
(a)constant
(b)zero
[✓ (c)changing]
(d)infinite

(12) On increasing the reverse bias to a large value in a pn junction diode, the current

(a) increases slowly
(b) remains fixed
(c) increases suddenly
(d)decreases slowly

(13) Which one of the following has the greatest energy gap?

(a)insulator
(b)conductor
(c)semi conductor
(d)all of above

(14) The value of resistivity for conductor is of the order of ________

(a)10^{-5} ohm metre
(b)10^{-6} ohm metre
(c)10^{-7} ohm metre
(d)10^{-8} ohm metre

(15) Thermions are ________

(a)protons
(b)positrons
(c)electrons
(d)photons

(16) Hole is equivalent to ____________

(a)a negative charge
(b)a positive charge
(c)a neutral particle
(d)an electron

(17) Which one of the following is not a donor impurity?

(a)antimony
(b)phosphorus
(c)aluminium
(d)arsenic

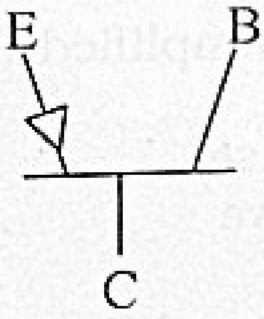
(18) Forward current through a semi conductor diode circuit is due to ________

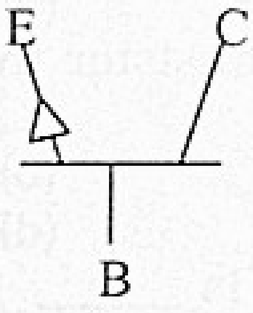
(a)minority carriers
(b)majority carriers
(c)holes
(d)electrons

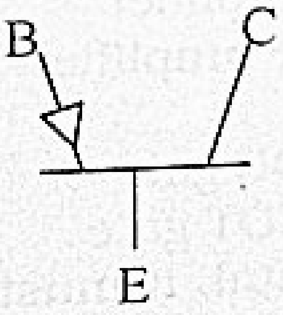
(19) In the transistor schematic symbol, the arrow __________

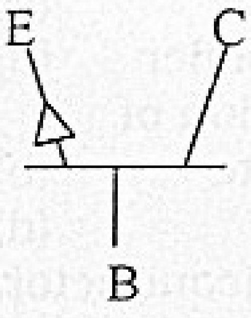
(a)is located on the emitter
(b)is located on the base
(c)is locate on the collector
(d)points form north to south

(20) The symbol of n-p-n transistor is ___________

(a)


(b)


(c)


(d)


(21) In full wave rectification, the output D.C. voltage across the load is obtained for____________

(a) The positive half cycle of input A.C.
(b) The negative half cycle of input A.C.
(c) The complete cycle of input A.C.
(d) All of the above.

(22) The semiconductor diode can be used as a rectifier because ________
(a) It has low resistance to the current flow when forward biased & high resistance when reverse biased.
(b) It has low resistance to the current flow when forward biased.
(c) It has high resistance to the current flow when reverse biased.
(c) Its conductivity increases with rise of temperature.
(d) In half-wave rectification, the output D.C. voltages is obtained across

(23) The load for ________
(a) The negative half cycle of A.C.
(b) The positive half cycle of A.C.
(c) The positive and negative half cycles
(d) Either positive or negative half of A.C.

(24) The device or circuit used for conversion of A.C. into D.C. is called ______
(a) An amplifier.
(b) A rectifier
(c) Filtering circuit
(d) Converter.

(25) The device used for conversion of D.C. to A.C. is called ________
(a) Converter
(b) Amplifier
[✓ (c) Inverter.]
(d) Oscillator.

(26) The specially designed semiconductor diodes used as indicator lamps in electronic circuits are ______
(a) The switch
[✓ (b) The light emitting diode]
(c) The photo diodes
(d) Solar cells.

(27) The specially designed semi-conductor diodes used as fast counters in electronic circuits are ______
(a) The light emitting diodes
[✓ (b) Photo diodes]
(c) Photo voltaic cell
(d) Solar cells.

(28) The alternating voltage is an example of ______
(a) A digital waveform
(b) An analogue waveform
(c) Discrete waveform
(d) None at all

(29) For amplification by a transistor the signal to be amplified is connected between the
(a) emitter and collector
(b) emitter and base
(c) base and collector
(d) any of the above

(30) The operational amplifier is ______
(a) A high gain amplifier
(b) A high-power amplifier
(c) A high resistance amplifier
(d) A low resistance amplifier

(31) NAND gate is a combination of
(a) AND gate and NOT gate
(b) AND gate and OR gate
(c) OR gate and NOT gate
(d) NOT gate and NOT gate

(32) To obtain an n-type semiconductor germanium crystal, it must be doped with foreign atoms whose valency is______
(a) 2
(b) 3
(c) 4
(d) 5

(33) To obtain a p-type semi-conductor Si Crystal must be doped with foreign atoms whose valency is ______
(a) 2
(b) 3
(c) 4
(d) 5

(34) The operation of a transistor requires ______

(a) That the emitter be heated
[✓ (b) That the base be heated]
(c) That the collector be heated
(d) None of the above

(35) In forward bias the width of potential barrier ________

(a) Increases
[✓ (b) Decreases]
(c)Remains same
(d) No effect

(36) The working of transistor as amplifier is similar to__________

(a) Step up transformer
(b) Step down transformer
(c) Three diodes in common
[✓ (d) Triode vacuum tube]

(37) The electronic circuits which implement the various logic operations are called __________

(a) Logic gates
(b) Boolean algebra
(c) Amplifier gain
(d) Logic functions

(38) An OP-AMP comparator is a circuit that compares the signal voltage on one of its inputs with a __________

(a) Non-inverting voltage at output
[✓ (b) Reference voltage on the other]
(c) Virtual input
(d) Output

(39) An OP-AMPs can amplify __________

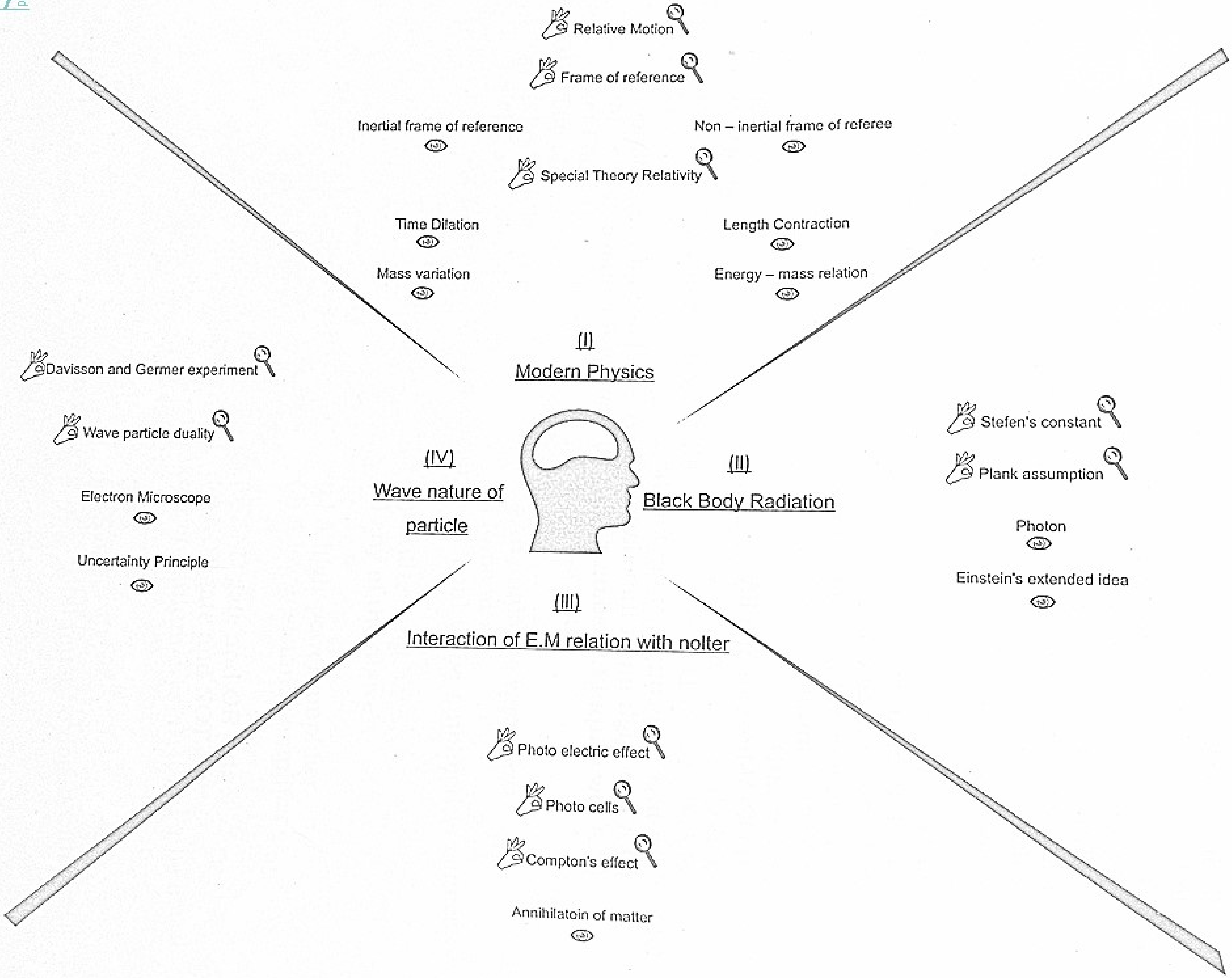
(a) D.C.
(b) A.C.
(c) Both A.C. & D.C.
(d) None of the above

(40) Non-inverting amplifier circuits have __________

[✓ (a) A very high input impedance]
(b) A very low input impedance
(c) A low output impedance
(d) None of the above

Chapter 19

DAWN OF MODERN PHYSICS



PHYSICS

Classical Physics

Modern Physics

Classical Physics	Modern Physics
It is based upon classical mechanics or Newtonian mechanics	It is based upon quantum mechanics
It consists of Newton's laws of motion and other laws dealing at macroscopic level. It deals at ordinary everyday life.	It is a discipline of laws of physics that deals at microscopic level as well as macro levels if care is consider as special case.
Span of classical physics include; 1-Newton's three laws of motion. 2-Newton's law of gravitation. 3-Four laws of thermodynamics. 4-K.M.T of matter 5- Gas laws. 6-Newton's cooling laws. 7-Maxwell's equation of e.m waves. 8-Faraday's law of electromagnetic induction. 9-Lenz's laws 10-Newton's law of gravitation 11-Coulombs law etc.	Span of modern physics includes; 1-Michelson's and Morley's findings. 2-Schiodinger wave equations. 3-De-Broglic hypothesis. 4-Bohr's ideas. 5-Heisenberg's uncertainty principle. 6-Plank's theory. 7- Special theory of relatively 8- General theory of relativity.

IDEAS OF MODERN PHYSICS

- Light is an electromagnetic wave
- Light consists of **photons**, each having energy E = hf
- Speed of light is a universal constant in vacuum that is independent of motion of source and observers.
- Absorption and emission of electromagnetic waves takes place in the form of packets of energy called **photons.**
- True laws of physics retain their mathematical form in all **inertial frame of reference.**
- All motions and rest are **relative.**
- There is nothing like **absolute rest** or motion.
- Wave - particle duality.
- Reaction takes some time to replay, after action.
- Matter waves are associated with moving particles.
- $E = mc^2$ Einstein Equation
- Photon is splitted into pair of electron and positron, process called pair **production.**
- Positron and electron are **annihilated to photon**.
- Position, momentum, energy and time can't be measured accurately at same time.

Chapter 19 Dawn of Modern Physics

RELATIVE MOTION

- The concept of **direction** is purely relative.
- The experiments give same results in same frame of reference. In different frames, give different results.

FRAME OF REFERENCE

The coordinate system x, y and z axes from where observation is made is called frame of reference.

- ***Inertial fame*** is that either it is at rest or moving **with uniform** velocity.
- ***Non inertial frame*** is that which is moving with accelerated motion.
- Earth may be considered as an inertial frame of reference for motion on Earth.

> **Do you know?**
>
> The frame of reference in which the laws of inertia are valid is called as inertial frame of reference.

THEORY OF RELATIVITY

- **In 1905**, Einstein put forward his theory of relatively.
- Special theory of relativity deals with inertial frames of reference.
- *Important Results of Special Theory of Relativity*

✓ $m = m_o / \sqrt{1 - v^2/c^2}$

✓ $l = l_o \sqrt{1 - v^2/c^2}$ (Lorentz Contraction)

✓ $t = t_o / \sqrt{1 - v^2/c^2}$ where v = relativistic speed

✓ $E = mc^2$

✓ All motions and rest are relative.

✓ No body moves with velocity **greater** than velocity of light.

For your information

At ordinary speed (as in common life) the results of special theory of relativity are

$$m = m_o$$
$$\ell = \ell_o \qquad \text{as } v \approx c$$
$$t = t_o$$

that is why we don't observe any change in length, mass and time in ordinary life.

NAVSTAR NAVIGATION SYSTEM

- Modern system of navigation satellites called **NAVSTAR** use results of **special theory of relativity.**
- The location and speed anywhere on Earth can be accurate up to 50m after 1hr flight and **2cms⁻¹** velocity with use of NAVSTAR.

BLACK BODY RADIATION

Black body is an ideal ***radiator*** *and ideal* ***absorber.***

- The emissive or absorptive power is **1.**
- Black body is very bad reflector
- Black body emits electromagnetic waves

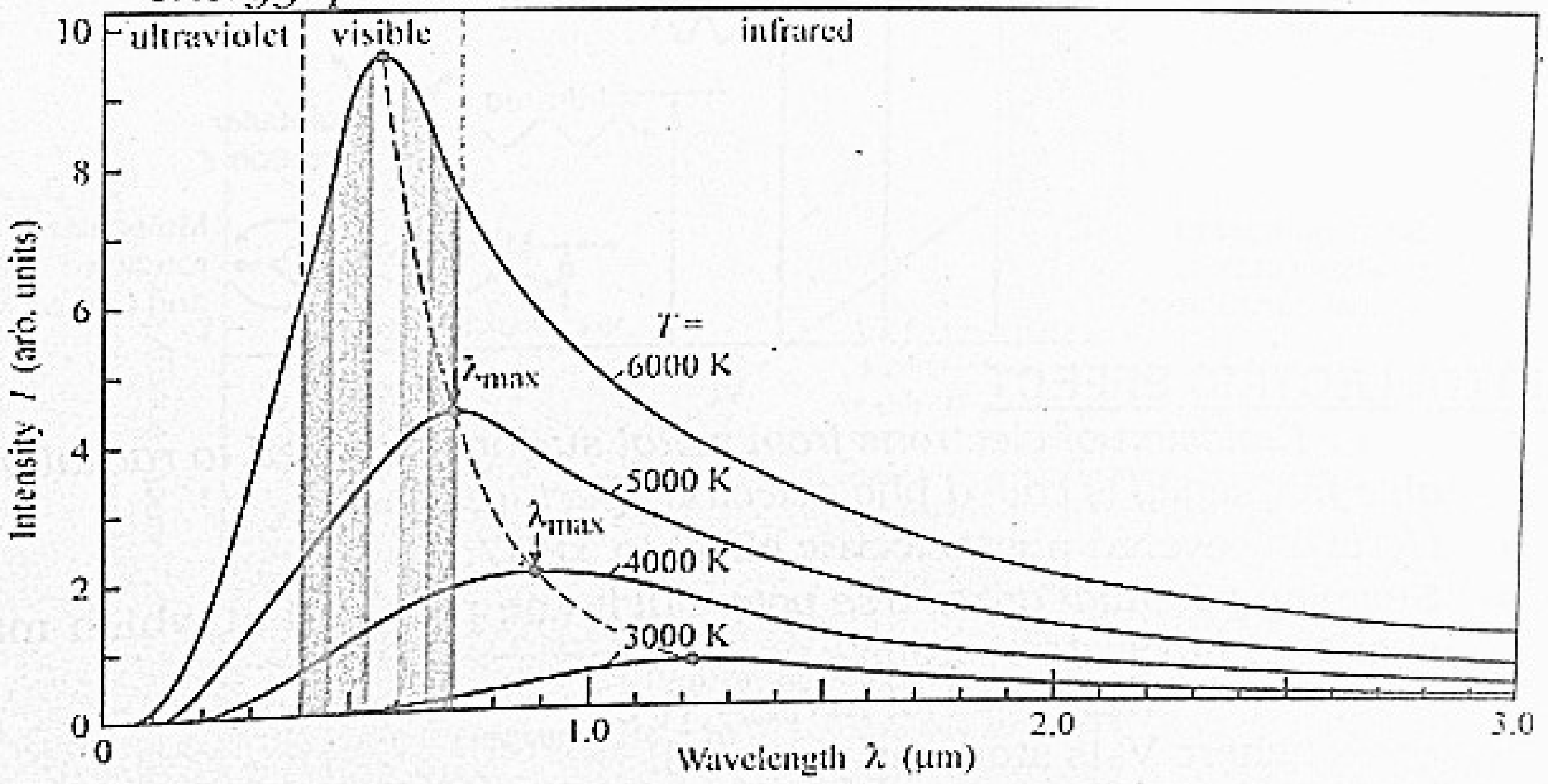
Intensity Distribution of Black Body

- ***Lummer*** *and* ***Pringsheim*** measured the intensity of emitted energy of different wavelengths.
- Curve shows the characteristics depending upon temperature.
- At a given temperature, the energy is not uniformly distributed in the **radiation** spectrum.
- $\lambda_{max} \times T = \text{constant} = 2.9\times10^{-3}\text{mK}$ so, $T \alpha 1/\lambda$
- The area of curve shows total amount of energy i.e. **emissive power.**
- Energy (area of curve) is directly proportional to the fourth power of Kelvin temperature i.e. ***Stephen- Boltzman law*** **is $E \alpha T^4$**

$$E = \sigma T^4$$

$$\sigma = 5.67\times10^{-8}\ \text{Wm}^2\text{K}^{-4} = \textbf{Stephen's constant}$$

- Shape of black body radiation curve is same and independent of material of the body.
- Classical attempts for explanation of black body radiations are given below.
  - ***Wein's*** *Displacement law* holds good for **shorter wavelength.**
  - ***Rayleigh*** *Jeans law* holds good at **longer wavelength.**
  - *Plank's quantum theory* explains the black body radiations that absorption and emission of radiation takes place in the form of packets of energy called quanta i.e. E = hf. *It holds good at all* ***wavelengths.***
  - *Max Plank receive noble prize in 1918 in physics for discovery of energy quanta .*



THE PHOTONS

- *Einstein presented the idea of light energy consisting of packets of* ***electromagnetic*** *energy.*

- Max plank explained the emission and absorption by the atoms from a black surface is in the form of indivisible packets called **quanta.**
- *Max plank put discontinuous* ***(granular)*** *nature of light.*
- The beam of light with wavelength λ consists of stream of photons traveling at speed c and carrier energy hf.
- As $E = mc^2$ & $E = hf$

  then $mc^2 = hf$

  or $mcc = hf$

  $mc = hf/c$

  As $mc = p$ and $f = C/\lambda$ P = momentum

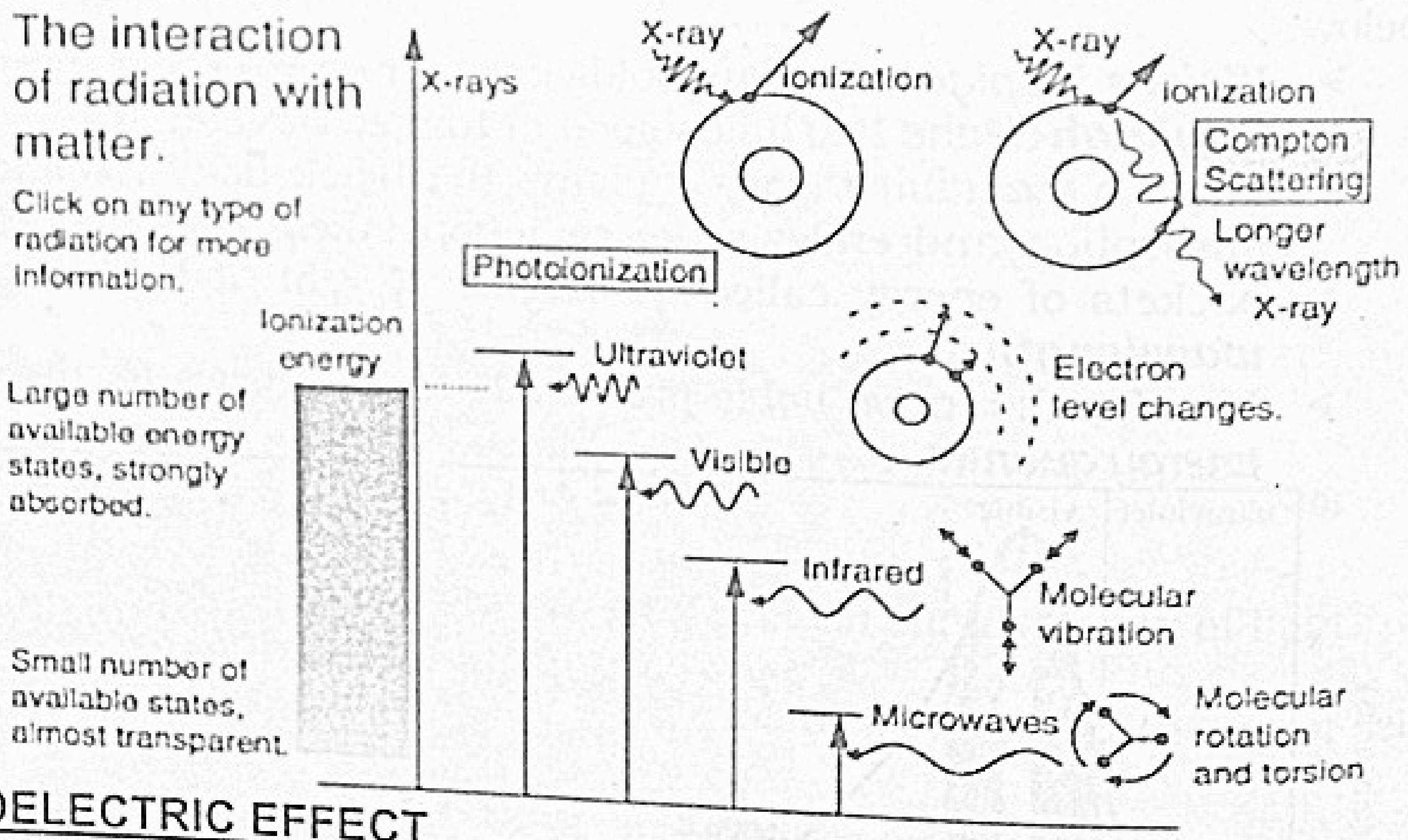
  then $p = h/\lambda$
- Emission or absorption of energy is applied to any **oscillating system.**

INTERACTION OF ELECTROMAGNETIC RADIATION WITH MATTER

It is of three types depending upon the energy of photon.

✓ Photo electric effect	**$hf<0.1MeV$**
✓ Compton effect	**$0.1MeV<hf<1MeV$**
✓ Pair production	**$hf>1MeV$**

For your information



The interaction of radiation with matter.
Click on any type of radiation for more information.
X-rays
X-ray
Ionization
X-ray
Ionization
Compton Scattering
Longer wavelength X-ray
Photoionization
Ionization energy
Large number of available energy states, strongly absorbed.
Ultraviolet
Electron level changes.
Visible
Infrared
Molecular vibration
Small number of available states, almost transparent.
Microwaves
Molecular rotation and torsion

PHOTOELECTRIC EFFECT

Emission of electrons from metal surface exposed to radiation of suitable frequency is called photoelectric effect.

- *Hertz* discovered photoelectric effect in **1887.**
- *Stopping potential or reverse potential* is the potential at which maximum energy photoelectron stops.

  $K.E_{max} = 1/2\ mV_{max}^2 = V_o e$

  where V_o is stopping potential.
- Minimum frequency, at which photoelectric effect starts, is called threshold frequency.

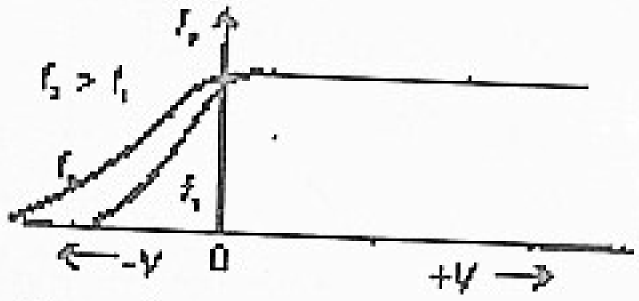
  $f_o = \phi/h \rightarrow \quad \phi = hf_o$

  where ϕ is **work function.**

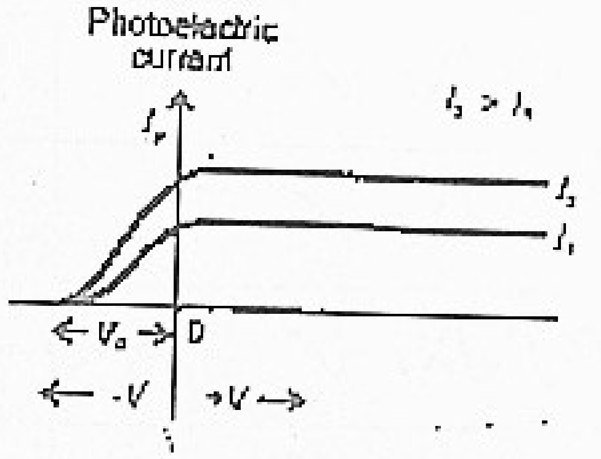
Work Function

The minimum energy required to liberate an electron from the metal surface is called work function.

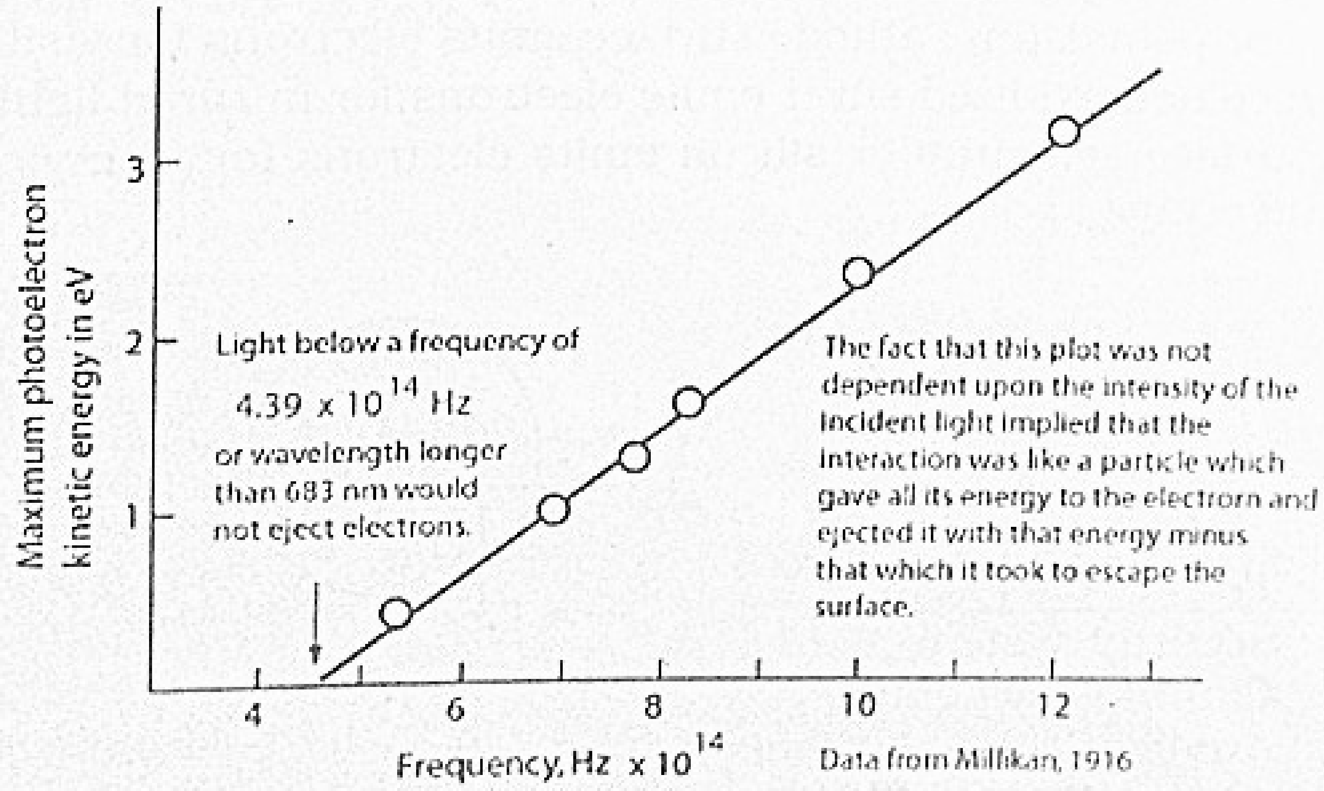
- *Ejection of photoelectrons depends on frequency not* ***intensity.***
- With increase in frequency K.E$_{max}$ increases but photoelectric current remains same.



- With increase in intensity photoelectric current increases but K.E$_{max}$ and stopping potential remains same.



- After ejection energy of photoelectron depends on freq. not intensity.
- Once photoelectric effect starts, the no. of photoelectrons depends only on intensity.
- *One photon can emit one photoelectron.*
- ***Graph of photoelectric effect***



Data from Millikan, 1916

- *Photoelectric effect equation* is given as;

$$1/2\ mV^2_{max} = hf - \phi$$

- *Photocell* is a practical application of photoelectric effect.

- Photoelectric effect can only be explained assuming the corpuscular nature of light.

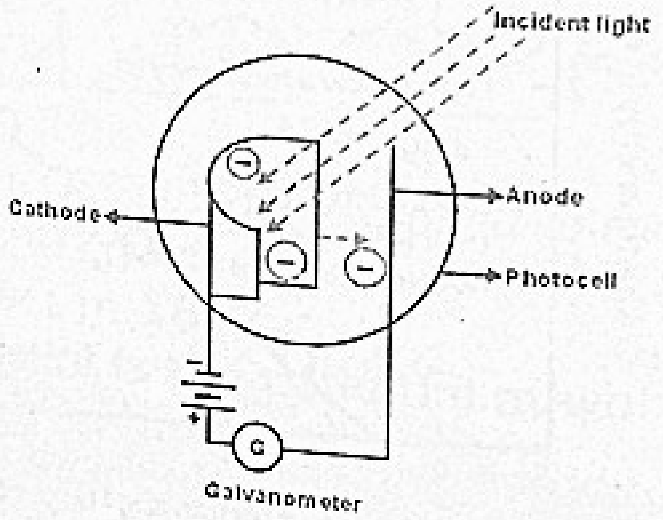
For your Information

A weak beam of radiations having frequency more than threshold frequency can eject a photo electron while an intense beam of frequency lesser than threshold cannot eject a photo electron.

Phenomenon	Can be explained in terms of waves.	Can be explained in terms of particles.
Reflection	∿∿∿ ✓	●→ ✓
Refraction	∿∿∿ ✓	●→ ✓
Interference	∿∿∿ ✓	●→ ⊗
Diffraction	∿∿∿ ✓	●→ ⊗
Polarization	∿∿∿ ✓	●→ ⊗
Photoelectric effect	∿∿∿ ⊗	●→ ✓

PHOTO CELL

- A photocell is based on **photoelectric effect.**
- *A simple photocell consists of a glass bulb with a thin* ***anode rod*** *and a* ***cathode*** *of an appropriate metal surface.*
- Sodium or potassium cathode surface emits electrons for visible light.
- Cesium coated oxidized silver emits electrons for infrared light.
- Some surface selenium or silicon emits electrons for ultraviolet rays, X-rays and γ-rays .



- *Applications of photocells*
  - ✓ Security system
  - ✓ Counting systems
  - ✓ Automatic door systems
  - ✓ Automatic street lighting
  - ✓ Exposure meter for photography
  - ✓ Sound tracks of movies
  - ✓ Solar panels in watches and other appliances

COMPTON EFFECT

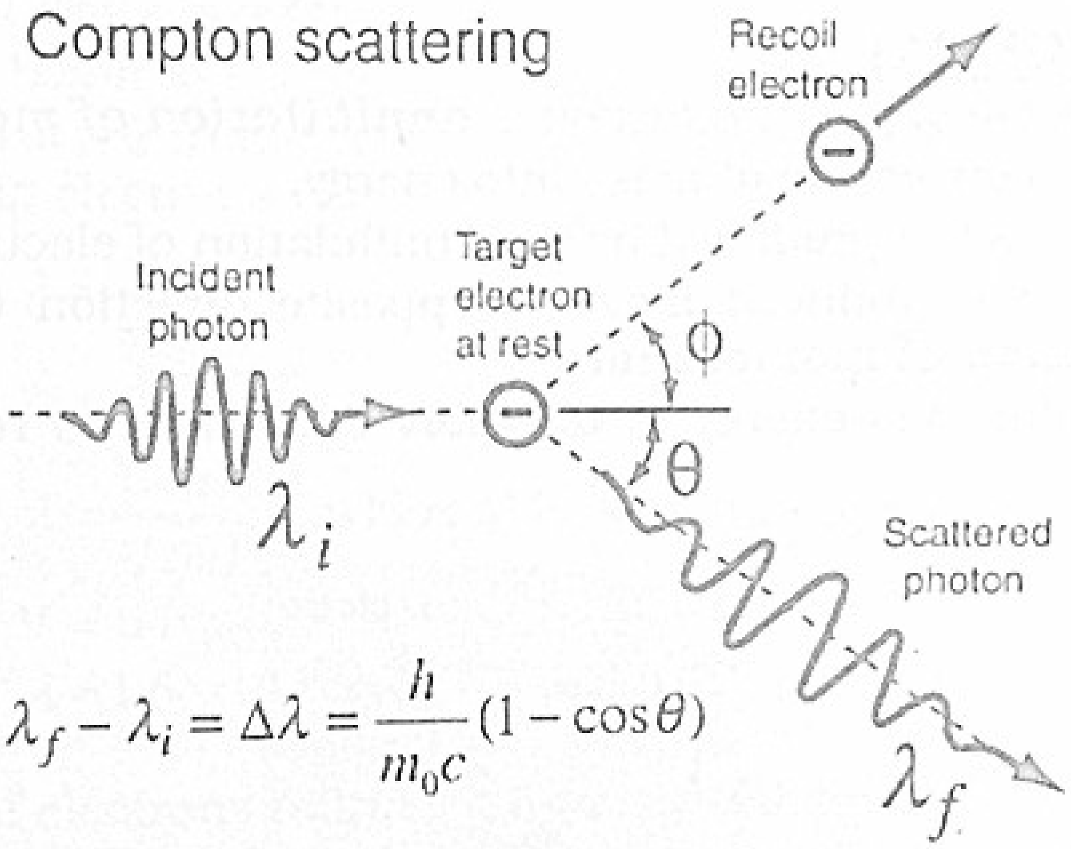
When a photon hits with an electron, it scatters with frequency less than that of incident photon; It is known as ***compton effect.***

- Usually X-ray photons are used because of high energy (≥ **17.5 KeV**).
- Change (increase) in wavelength is called ***Compton shift.***

$\Delta\lambda = \lambda_f - \lambda_i$

$\Delta\lambda = h/m_oC\ (1-\cos\theta)$.

- $\Delta\lambda = h/m_oC = 2.43 \times 10^{-12}$ m is called ***Compton wavelength.***
- $\Delta\lambda = 0$ when $\theta = 0°$.
- $\Delta\lambda = h/m_oC$ when $\theta = 90°$.
- $\Delta\lambda = 2h/m_oC$ when $\theta = 180°$.



$$\lambda_f - \lambda_i = \Delta\lambda = \frac{h}{m_0C}(1-\cos\theta)$$

- *Photoelectric effect and Compton effect are strong evidences that e.m waves behave as* ***particle (photon).***
- *Compton effect proves* ***photon*** *theory of light.*

PAIR PRODUCTION

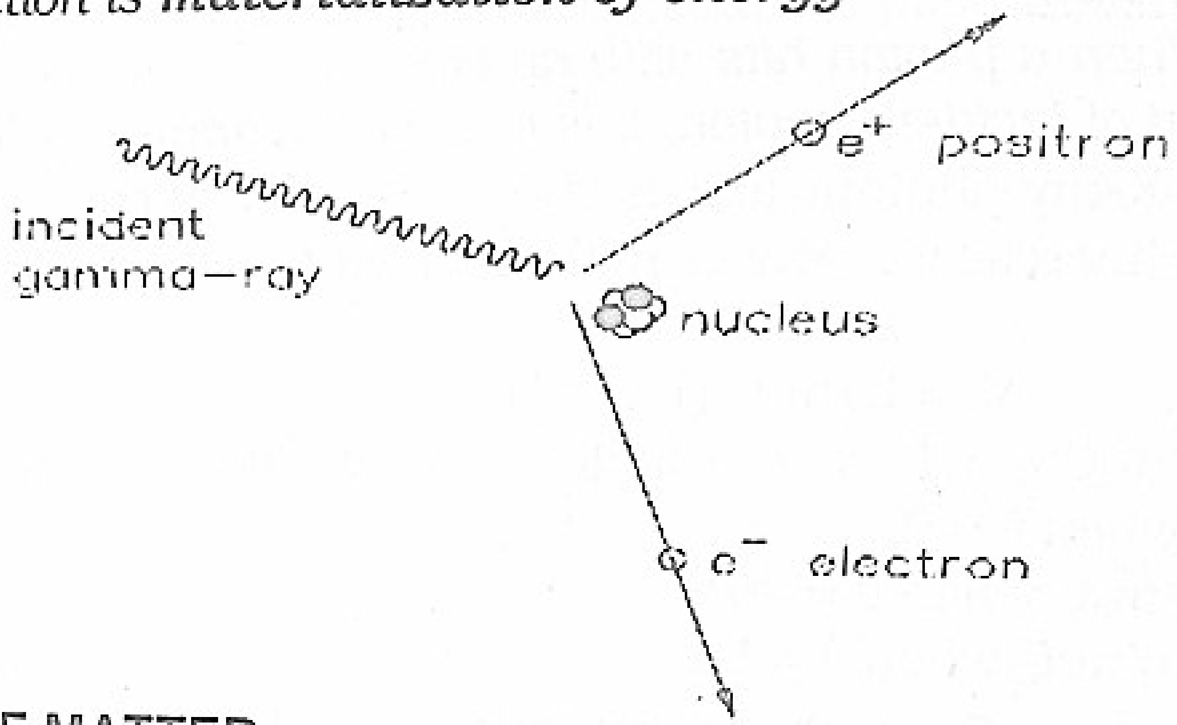
Decomposition of photon into electron, position pair is called pair production.

- Pair production can takes place only if photon energy is greater than **1.02 MeV.**
- *Energy equation for pair production* is given as:

$hf = 2m_oc^2 + K.E_{e-} + K.E_{e+}$

- *Rest mass energy* of electron or positron is $\mathbf{m_oc^2}$ (**= 0.51 MeV**).
- Condition for pair production is that $hf > 2m_oc^2$
- *Pair production can not take place in* ***vaccum***
- *The interaction usually takes place in the electric field in the vicinity of a heavy nucleus so that there is a particle to take up recoil energy and momentum is conserved.*

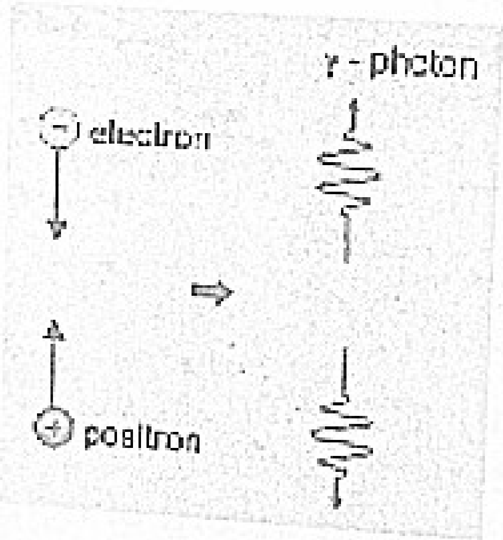
- *Pair production is **materialization of energy***



ANNIHILATION OF MATTER

Inverse of pair production is ***annihilation of matter.***

- It involves conversion of mass into energy.
- Two photons are produced by the annihilation of electron and positron
- Two photons produced move in opposite direction to obey the law of **conservation of momentum.**
- Each photon has energy of **0.51Mev** equivalent to rest mass energy of electron.



ANTIMATTER

- ***P.A.M Dirac*** theoretically predicted antimatter in 1928.
- *Anderson* discovered positron during study of spectrum of cosmic rays in 1932.
- *Every antiparticle has same mass, same spin but opposite magnetic moment and charge to its respective particle*

Particle	*Antiparticle*
Electron	*Positron*
Proton	*Antiproton*
Neutron	*Antineutron*
Neutrino	*Antineutrino*
Earth	*Black hole*

De-BROGLIE'S HYPOTHESIS (Wave particle duality)

All the moving particles behave as waves called matter waves or particle waves. The wave length associated with moving particles is given by

$$\lambda = h/mV$$

mV = momentum of particles

$\lambda = h/P$

$\lambda \alpha 1/m$

$\lambda \alpha 1/v$

An object of large mass and ordinary speed has such a small wavelength that its wave effects such as interference and diffraction are negligible.

Davisson and Germer Experiment

- ***Germer** and **Davisson*** using low energy electron beam provided experimental confirmation of **de-Broglie's hypothesis**. They showed that electrons are diffracted from metal crystals in exactly the dame manner as X – rays or any other wave.
- The electron beam of energy Ve is made incident on a nickel crystal. The beam diffracted from crystal surface. The wavelength associated with the moving electrons is given as:

$$\lambda = \frac{h}{mv}$$

$$mv = \sqrt{2mVe}$$

$$\lambda = \frac{h}{\sqrt{2mVe}}$$ where V is accelerating potential

V = 54v

$$\lambda = 1.66x10^{-10} m$$

- This beam of electrons diffracted from crystal surface was obtained for a glancing angle of 65°. According to Bragg's equation $2d\,sin\theta = m\lambda$

  For 1st order diffracting m = 1

  For nickel d = 0.91×10^{-10}m

  Which gives $\lambda = 1.65\times10^{-10} m$
- Prince Louis Victor de Broglie received the 1929 noble prize in physics Clinton Joseph Davisson and George Paget Thomson shared the Nobel Prize in 1937 for their experimental confirmation of the wave nature of particles.
- Electron microscope is a practical application of wave particles duality.

HEISENBERG'S UNCERTAINTY PRINCIPLE

It states that following pairs of quantities can't be measured with perfect accuracy at same time.

- *Linear momentum and position*
- *Energy and time*

Such quantities are called conjugate quantities.

Mathematically,

$$\Delta p \simeq \frac{h}{\lambda}$$

$$\Delta x = \lambda$$

$$\Delta p \,.\, \Delta x = h$$

$$\Delta E \,.\, \Delta t = h$$

- To increase accuracy in measuring position, we should use short wavelength.
- To increase accuracy in measuring momentum, we should use long wavelength.

IMPORTANT CONSIDERATIONS

- A ball falling freely appears to fall straight to **stationary observer** and falling along curved path to moving observer. It is due to relative motion.
- If $V = 0.999C$ then $m = 22.4\ m_o$
- Millikan determined the values of 'e' and 'h'.
- Human body emits e.m waves in infrared region at only 310K.
- If $V \geq 2.6 \times 10^8$ m/s, then $l = l_o / 2$ & $m = 2\ m_o$

PRACTICE EXERCISE

30 min Time Yourself

(1) U.V radiation of 6.2eV falls on an aluminium surface, K.E of fastest electron emitted is (work function = 4.2eV)
(a)3.2×10^{-21} J
(b)7×10^{-25}J
(c)9×10^{-32}J
(d)3.2×10^{-19}J

(2) A photoelectric cells converts
(a)light energy to elastic energy
(b)electric energy to light energy
(c)light energy to mechanical energy
(d)light energy to electric energy

(3) The minimum wavelength of the x-rays produced by electrons accelerated through a potential difference of V volts is directly proportional to
(a) $\sqrt{V}$
(b) V^2
(c) $\frac{1}{\sqrt{V}}$
(d) $\frac{1}{V}$

(4) An observer shoots parallel to a meter stick at very high (relativistic) speed and finds that the length of meter stick is ____________
(a)greater than one meter
(b)less than one meter
(c)one meter
(d)a foolish question

(5) 0.001 kg mass will be equivalent to __________
(a)2.50 GWh
(b)25.00 GWh
(c)0.26 GWh
(d)250 GWh

(6) Which one of the following radiations has the strongest photon?
(a)T.V waves
(b)micro waves
(c)X-rays
(d)γ-rays

(7) The photoelectric effect of a certain metal is 3000 angstrom. If the radiation of 2000 angstrom is incident on the metal
(a)electrons will be emitted
(b)positrons will be emitted
(c)protons will be emitted
(d)none of the above

(8) Linear momentum of a photon is ________
(a)zero
(b)$h\nu/c^2$
(c)$h\nu/c$
(d)$c^2/h\nu$

(9) A device based on photoelectric effect is called__________
(a)photo sensitive detection
(b)photo diode
(c)photosynthesis
(d)photo cell

(10) As the intensity of incident light increases
(a)photoelectric current increases
(b)photo electric current decreases
(c)K.E of emitted photo electrons decreases
(d)K.E of emitted photo electrons increases

(11) Stopping potential for a metal surface in case of photoelectric emission depends on ________

(a)the threshold frequency for the metal surface

(b)the intensity of incident light

(c)the frequency of incident light and work function of the metal surface

(d)all of the above

(12) Select an alternative from of uncertainly principle from the following________

(a)$\Delta\lambda \approx h/m_oc(1-\cos\phi)$ (b)$\Delta E \, . \, \Delta t \approx h$

(c)$mc^2=hv$ (d)any of above

(13) The slope of frequency of incident light and stopping potential for a given surface will be

(a)h/e (b)hc

(c)h (d)e

(14) If a material object moves with speed of light, its mass becomes________

(a)equal to its rest mass (b)double of its rest mass

(c)infinite (d)zero

(15) As the temperature of black body is raised, the wavelength corresponding to maximum intensity ________

(a)shifts towards longer wavelength

(b)shifts towards shorter wavelength

(c)remain the same

(d)shifts towards longer as well as shorter wavelengths

(16) Rest mass of a photon is ________

(a)infinite (b)zero

(c)very small (d)1.67×10^{-27}kg

(17) The name of the photon for quantum of light was proposed by ________

(a)Ampere (b)Plank

(c)Thomson (d)Einstein

(18) Einstein's photoelectric equation is given by ________

(a)$1/2 \, mv_{max}^2=hf+\phi$ (b)$1/2 \, mv_{max}^2-hf=\phi$

(c)$1/2 \, mv_{max}^2=hf-\phi$ (d)all of above are incorrect

(19) In Compton scattering, the change in wave length is max. if________

(a)angle of scattering is 90° (b) angle of scattering is 60°

(c) angle of scattering is180° (d) angle of scattering is zero

(20) Davison Germer experiment indicates________

(a)interference (b) polarization

(c) electron diffraction (d) refraction

(21) A photon is ________

(a) a unit of energy

(b) a positively charged particle

(c) a quantum of electromagnetic radiation

(d) a unit of wavelength

(22) Planck's work was connected with

(a) wave nature of matter (b) photoelectric effect

(c) structure of atom (d) quantum nature of radiation

(23) If the wavelength of incident radiation in a photoelectric experiment is decreased then
(a) the photoelectric current will decrease
(b) the photoelectric current will increase
(c) the stopping potential will decrease
(d) the stopping potential will increase

(24) The speed of cathode rays is
(a) Equal to speed of light (b) Greater than speed of light
(c) Less than speed of light (d) None of these

(25) The ratio of e/m of a proton to that of an alpha particle is
(a) 1:1 (b) 1:4
(c) 1:2 (d) 1:1/4

(26) According to special theory of relativity, time is not absolute quantity. This result applies to ________ timing processes
(a) physical (b) chemical
(c) biological (d) all

(27) If a photon is reflected from the mirror, then the change in momentum of each photon is ________
(a) Zero (b) $2\frac{h}{\lambda}$
(c) $\frac{h}{\lambda}$ (d) Ft

(28) If n number of photon are striking on a metal surface, then total momentum exerted is __________
(a) $\frac{nh}{\lambda}$ (b) $\frac{2nh}{\lambda}$
(c) Zero (d) nFt

(29) A photon of wavelength 900nm behaves like a particle of mass_______
(a) 5.53×10^{-36}kg. (b) 0 kg.

(c) 2.46×10^{-36}kg. (d) 1.84×10^{-44}kg.

(30) The velocity of a particle of mass m of de-Broglie wavelength λ is _______
(a) $\frac{2h}{m\lambda}$ (b) $\frac{m\lambda c^2}{h}$
(c) $\underline{2m\lambda c^2}$ (d) h

(31) In Davisson-Germer experiment, the diffracted proton from crystal shows___________
(a) Particle property. (b) Wave property.
(c) Light property. (d) Quantum property.

(32) If a diffraction grating is placed in the path of a light beam, it reveals____
(a) Wave property. (b) Particle property.
(c) Energy particle. (d) Electromagnetic wave property.

(33) In electron microscope, we use energetic particles because of ______
(a) Penetrating power is high. (b) Kinetic energy is large.
(c) Wavelength is very short. (d) All the above reasons.

(34) The resolution of 50 KV electron microscope is
(a) 0.2 to 0.5 μm (b) 0.5 to 1 nm
(c) 0.5 to 1 μm (b) 0.2 nm

(35) A three dimensional image is obtained by ___________
(a) Electron microscope. (b) Scanning electron microscope.
(c) Magnetic imaging. (d) None of the above.

(36) Which of the following is not a form of uncertainty principles

(a) $\Delta x \Delta P \simeq h$ (b) $\Delta E \Delta t \simeq h$

(c) $m\Delta x\Delta v = h$ (d) none

(37) For confinement of electron in a box of radius 10^{-14}m, the electron speed should be ________

(a) 10^7m/sec.

(b) Should be greater than speed of light.

(c) Be zero.

(d) Not be wavelike.

(38) The energy radiated is directly proportional to fourth power of Kelvin's temperature is________

(a) Karl-wein's law. (b) Reyleigh Jeans law.

(c) Stephens law. (d) Planck's.

(39) Compton effect proves the ________

(a) Photon theory of light. (b) Dual nature of light.

(c) Wave nature of light. (d) Uncertain nature of light.

(40) Electron moves in the orbit as ________

(a) Simple vibratory motion.

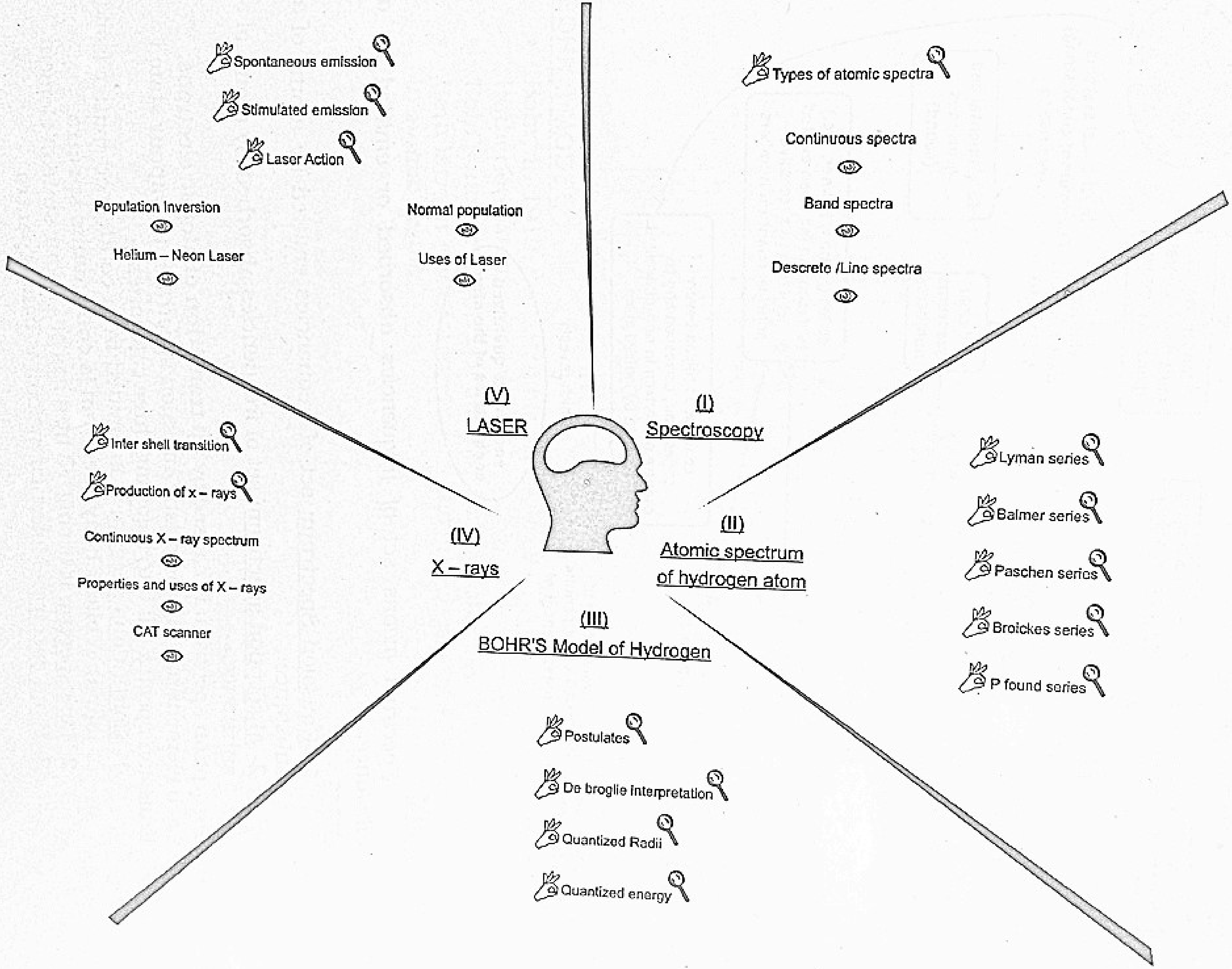
(b) Standing wave motion.

(c) Vibratory motion like up and down.

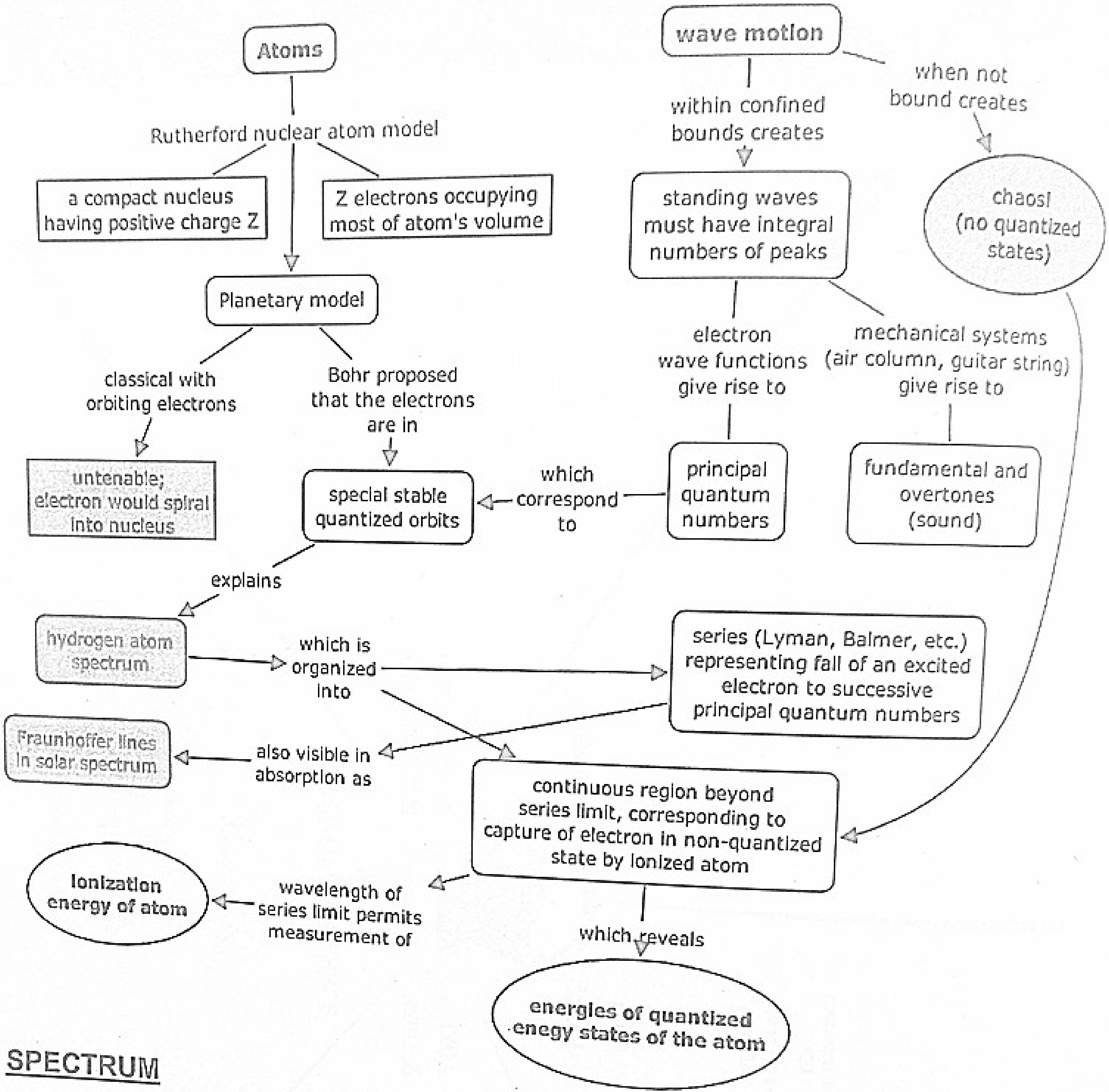
(d) S.H.M like sound.

Chapter 20

ATOMIC SPECTRA



Chapter 20 Atomic Spectra


Atoms
Rutherford nuclear atom model
a compact nucleus having positive charge Z
Z electrons occupying most of atom's volume
Planetary model
classical with orbiting electrons
untenable; electron would spiral into nucleus
Bohr proposed that the electrons are in
special stable quantized orbits
explains
hydrogen atom spectrum
which is organized into
series (Lyman, Balmer, etc.) representing fall of an excited electron to successive principal quantum numbers
also visible in absorption as
Fraunhoffer lines in solar spectrum
continuous region beyond series limit, corresponding to capture of electron in non-quantized state by ionized atom
wavelength of series limit permits measurement of
Ionization energy of atom
which reveals
energies of quantized enegy states of the atom
wave motion
within confined bounds creates
standing waves must have integral numbers of peaks
when not bound creates
chaos! (no quantized states)
electron wave functions give rise to
principal quantum numbers
which correspond to
mechanical systems (air column, guitar string) give rise to
fundamental and overtones (sound)

SPECTRUM

Spectrum means set of frequencies absorbed or emitted by a substance.

- ***Types***

  1- Emission Spectrum: set of frequencies emitted by atoms of a substance.

  2- Absorption spectrum: set of frequencies absorbed by atoms of a substance.

- Absorption spectrum is caused by up **transition** of atomic electrons.
- Each element has characteristic emission spectra in its vapour state.
- Emission spectra fall into following three categories: -

  1- Continuous spectra: It is emitted from condensed matter (solid or liquid). A **black body** spectrum is **continuous spectra.**

  2- Line spectra: It is emitted by a gas or vapour state of element.

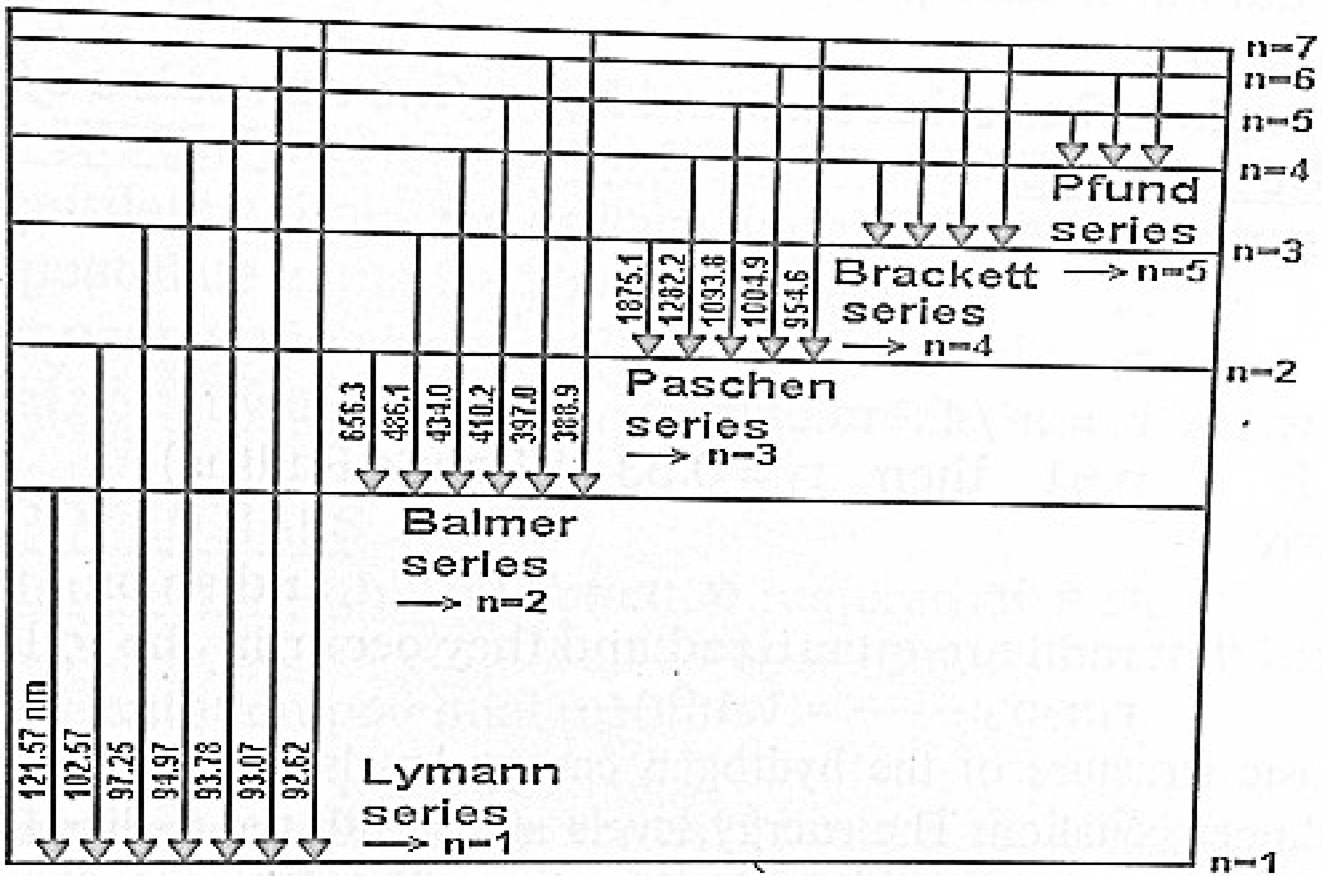
  3- Band spectra:- Molecular spectra is **band spectra**

SPECTRUM OF HYDROGEN

Emission spectrum of H-atom consists of five series or 5 sets of spectral lines.

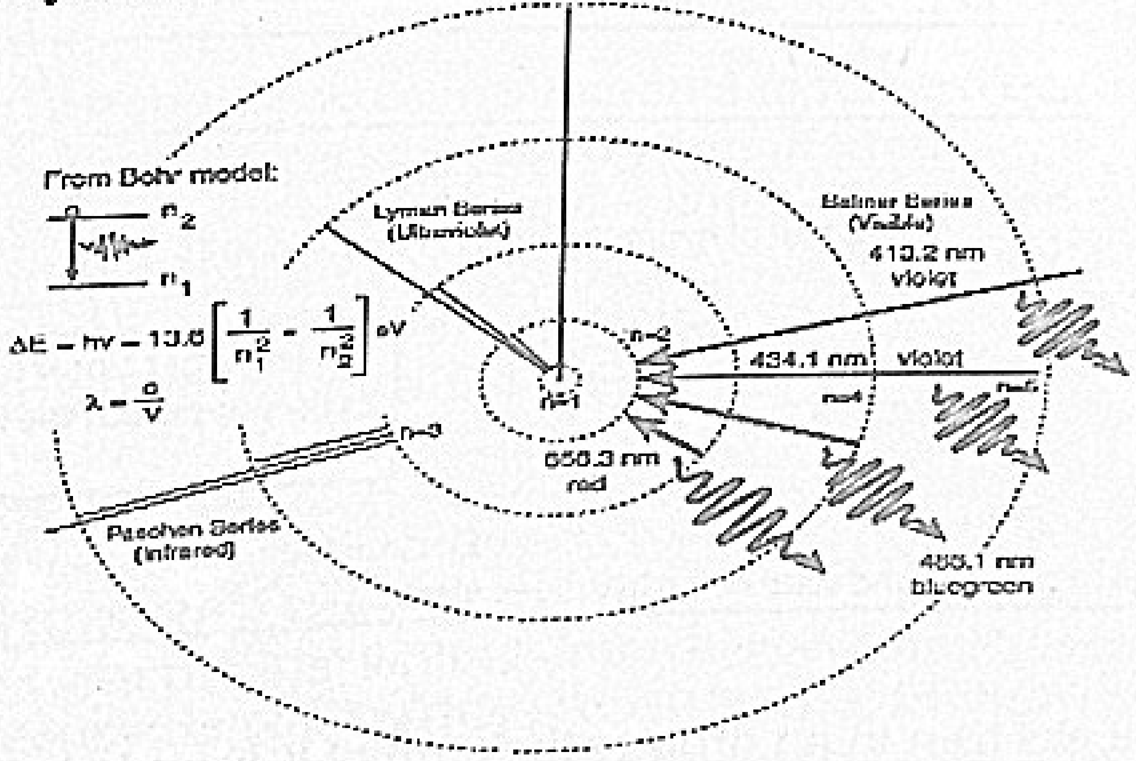
Name of series	Formula	Region	Transition
Lyman	$1/\lambda_n = R_H(1/1^2 - 1/n^2) n > 1$	Ultraviolet	From n>1 to n=1
Balmer	$1/\lambda_n = R_H(1/2^2 - 1/n^2); n > 2$	Visible	From n>2 to n = 2
Paschen	$1/\lambda_n = R_H(1/3^2 - 1/n^2); n > 3$	Infrared	From n>3 to n = 3
Bracket	$1/\lambda_n = R_H(1/4^2 - 1/n^2); n > 4$	Infrared	From n>4 to n = 4
Pfund	$1/\lambda_n = R_H(1/5^2 - 1/n^2); n > 5$	Infrared	From n>5 to n=5

- All one-electron atoms have atomic spectra like hydrogen atom.
- Spectral lines get closer with increase in value of n until they merge at n = α called *series limit.*



BOHR'S MODEL

- Bohr, in 1913, proposed his atomic model, to remove **objections** against Rutherford atomic model.
- Bohr's atomic model is a mixture of classical and modern physics.
- Both laws of classical mechanics and quantum mechanics are applicable to atomic system.


From Bohr model:
n_2
n_1
$\Delta E = h\nu = 13.6\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] eV$
$\lambda = \frac{c}{\nu}$
Lyman Series (Ultraviolet)
Balmer Series (Visible)
410.2 nm violet
434.1 nm violet
656.3 nm red
486.1 nm bluegreen
Paschen Series (Infrared)
n=1
n=2
n=3
n=4
n=5

- ***Main points of Bohr's atomic model***

1- An electron can revolves only in those orbits in which their angular momentum is **integral multiple of unit** $h/2\pi$.

$$mV_nr_n = nh/2\pi$$

2- As long as electron remains in an allowed orbit, its energy remains constant, in spite of fact that continuously it undergoes angular acceleration.

3- Emission or absorption of energy from atom takes place only when its electron undergoes down or up transition between two allowed orbits.

$$\Delta E = E_n - E_p$$
$$hf = E_n - E_p$$

- Bohr's atomic model produced good results for H-atom and for one-electron atom.
- *It can't explain **fine structure** and **hyperfine structure of spectrum**.*

BOHR'S CALCULATIONS

- ***Radius** of nth orbit* of the atom is given as;

$$r_n = n^2h^2/4\pi^2 m e^2 k$$
$$r_n = r_o n^2$$

where $r_o = h^2/4\pi^2 m e^2 k$

If $n = 1$ then $r_1 = 0.53$ A°(Bohr's Radius)

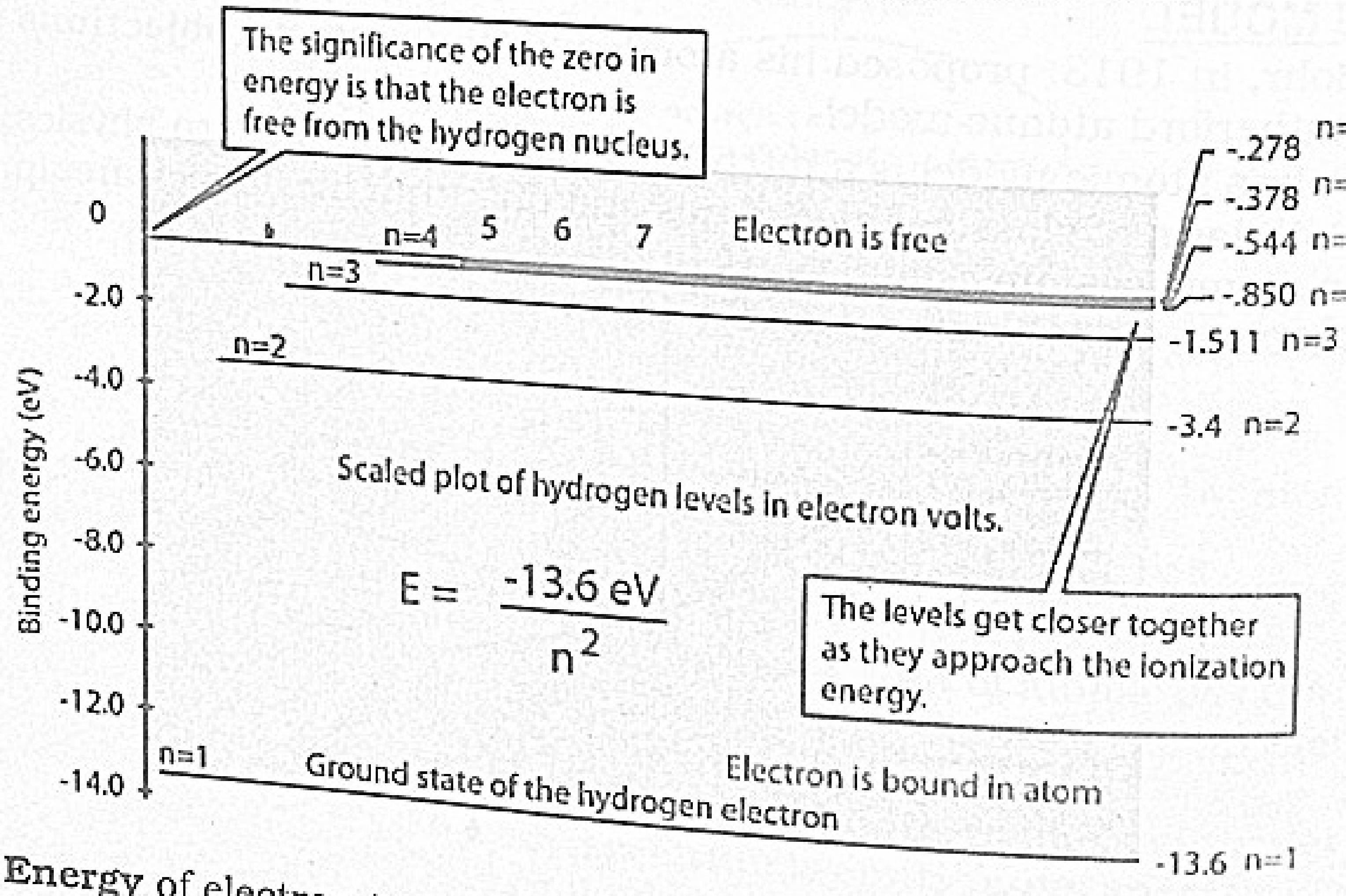
Similarly,

$r_2 = 4r_1$ & $r_3 = 9 r_1$ and so on.

It shows that radii are **quantized** and they occur in the following ratio:

$r_1:r_2:r_3$:------ = 1:4:9 -----

- The basic structure of the hydrogen energy levels can be calculated from the Schrodinger equation. The energy levels agree with the earlier Bohr model, and agree with experiment within a small fraction of an electron volt.


The significance of the zero in energy is that the electron is free from the hydrogen nucleus.
0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
-14.0
Binding energy (eV)
n=4
5
6
7
Electron is free
n=3
n=2
n=1
-.278 n=7
-.378 n=6
-.544 n=5
-.850 n=4
-1.511 n=3
-3.4 n=2
-13.6 n=1
Scaled plot of hydrogen levels in electron volts.
$E = \frac{-13.6 \text{ eV}}{n^2}$
The levels get closer together as they approach the ionization energy.
Ground state of the hydrogen electron
Electron is bound in atom

- **Energy** of electron in an orbit is the sum of K.E and electrical P.E.

$$E_n = KE + PE$$

$$K.E = Ke^2 / 2r_n$$
$$P.E = -Ke^2 / r_n$$
$$E_n = -ke^2 / 2r_n$$

- *Energy of electron* in nth orbit is given as;

$$E_n = E_o / n^2$$

Where $E_o = 2\pi^2 e^4 mk^2 / h^2 = 13.6eV$

$E_1 = -13.6eV$ for $n = 1$

$E_2 = -3.4$ eV for $n = 2$

$E_3 = -1.51$ eV and so on. for $n = 3$

- Graph of equation $E_n = -E_o/n^2$ is called ***energy level diagram.***
- Formula for the wavelength of nth orbit is given as;

$$1/\lambda_n = R_H (1/p^2 - 1/n^2)$$

Where $n > p$

R_H = Rydberg's constant $= 1.0974 \times 10^7$ m^{-1}.

De-BROGLIE'S INTERPRETATION OF BOHR'S ORBIT

- Third postulate of Bohr's atomic model is deduced from Plank's thesis.
- Second postulate is justified by de-Broglie

⇒ Electrons move in orbits in the shape of standing waves

⇒ Orbital velocity of electron in innermost orbit is **2.19×10^6 m/sec,**

ENERGIES & POTENTIALS

- **Excitation potential**: The potential required to raise the electron from ground state to higher state. e.g. for hydrogen,

1st excitation potential = 10.2 eV

2nd excitation potential= 12.1eV

- **Ionization potential:** The potential required for ionization of atom e.g. for hydrogen, **13.6 V** is ionization potential.

Note:

*1-There is a large no. of excitation potentials and only limited no. of **ionization potentials.***

2-Each next ionization potential is greater than its preceding one.

- **Excitation energy**: The energy required to raise the atom from ground state to higher state.
- **Ionization energy**: The energy required to remove electron from atom
- **Three ways for excitation / ionization of atom**

1- Photo ionization/excitation: photon of specified energy is incident.

2- Bombardment ionization / excitation: charged particle e.g. electron is incident on atom.

3- Thermal ionization/excitation: heat is provided.

X-RAYS

CHARACTERISTIC X-RAYS

- When core electron is ionized from heavy atom, then electron jumps down to occupy its place. This process is called ***inner shell transition.***
- *Inner shell transition is the origin of **characteristics X-rays.***

- X-rays are e.m waves having wavelength 1A° to 0.5A°.
- Characteristic X-rays are emitted due to down **transition** of electron.
- A characteristic X-rays appear as discrete lines on **continuous spectrum.**
- The X-rays produced due to transitions to K- shell are called *primary X-rays*. e.g. K_α, K_β, K_γ etc.

  $$hf_{k\alpha} = E_l - E_k$$
  $$hf_{kB} = E_m - E_k$$

  Such X-ray photons are emitted due to transition from L, M, N orbits to K-shell respectively.

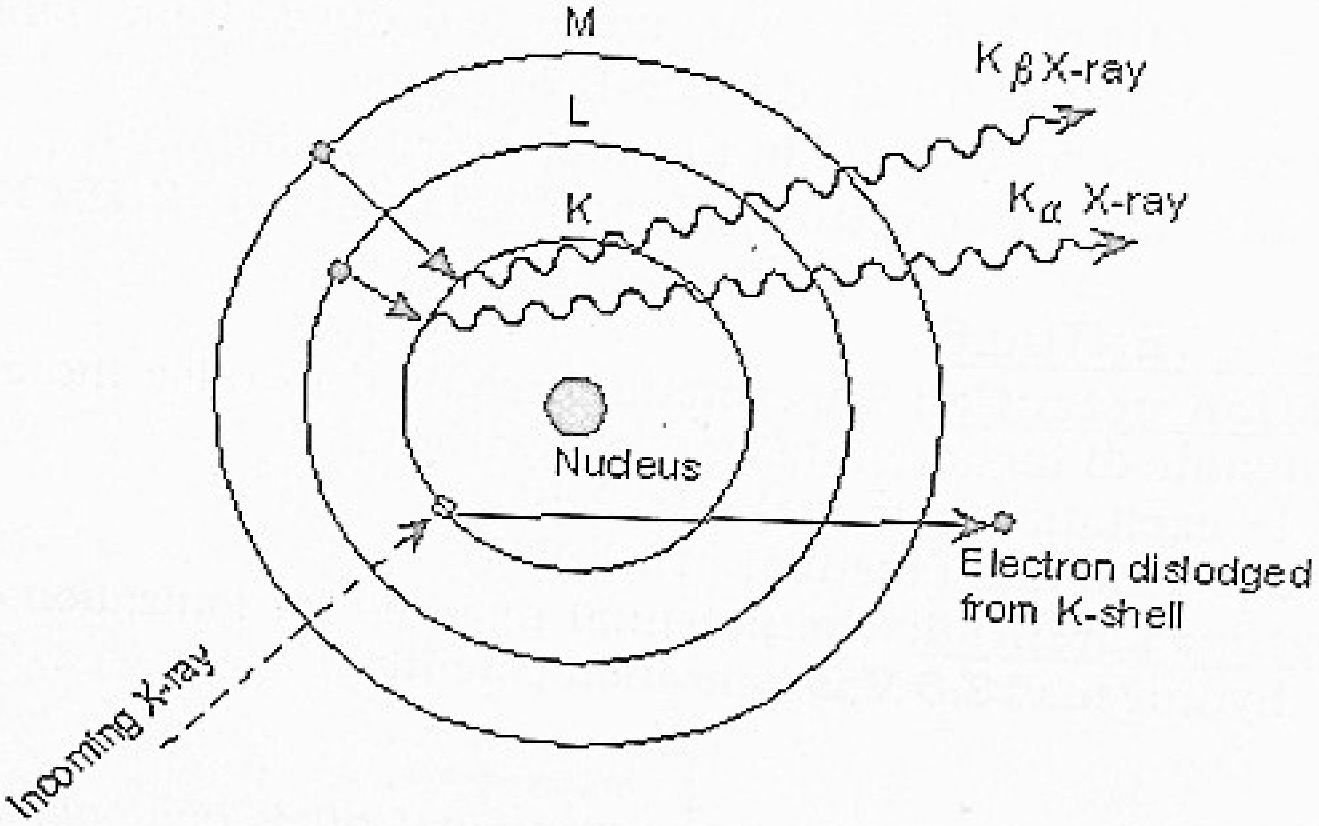
Ejected electrons

- A German physicist *Roentgen* discovered X-rays in December 1895.

CONTINUOUS X-RAYS SPECTRUM

- The continuous spectrum is due to : electrons **bremsstrahlung** or **breaking radiation.**

Scattered electrons



- *Accelerating charge emits electromagnetic radiation.*
- Due to deceleration of electrons in the target, X-ray radiation is emitted called *continuous background radiation or breaking radiation.*

  $$Ve = hf_{max}$$

- Continuous background radiations are of relatively smaller wavelength.

X-RAY PRODUCTION

- Gas filled X-ray has three drawbacks:
  1- Quality can't be controlled.
  2- Pressure decreases, so does X-rays intensity.
  3- 98% of incident electron energy is wasted as heat and only 2% is converted in to X-rays.
- Modern X-ray unit consists of following main parts: -

Source: It is step up transformer that produces high voltage.

Target: It is a piece of heavy metal with large atomic no. like cadmium.

Filament: It is an electron source. It consists of concave shaped metal heated by **D.C operated heater** (100 mA to 500 mA).

Copper rod: It conducts out heat.

Cooling fins: It is a cooling spring in which cooling water or oil circulates.

Biological shield: It is lead case covering the whole assembly.

Window: It is a transparent window for the escape of X-rays.

- Intensity of X-rays is controlled by heater current (100 mA → 500 mA).
- Quality of X-rays is controlled by source voltage (25 KV → 100KV).

PROPERTIES OF X-RAYS

1- X-rays are not affected by **electric** and **magnetic** fields.
2- Frequency is greater than **ultraviolet**.
3- Straight-line propagation.
X- rays exhibits
4- Reflection.
5- Refraction.
6- Interference.
7- Diffraction (by NaCl crystal)
8- Polarization.
9- Pass through certain opaque materials.
10-Ionization.
11-Photoelectric effect.
12-Compton effect.
13-Blackening of photographic plate.
14-Damage to living cell

Do you know?

The oil of higher specific heat flows in the cooling fines of x-ray production apparatus to sink the large amount of heat produced by head on collision of particles in x-ray generation

USES OF X-RAYS

1-Fracture study. (Shadow Photography)
2-Medical diagnosis (such as **tuberculosis**).
3-Medical treatment (such as cancer).
4-Hidden things can be located (such as **weapons** and contraband things).
5-Research field (such as X-ray diffraction for crystal structure).
6-Industrial uses (such as to locate **internal defects**)
7-Authenticity of paintings.
8- CAT-scanner: CAT stands for computerized axial topography. The x-ray source produces a thin fan shaped beam that is detected on the opposite side of the subject by an array of several hundred detectors in a line. Tumors, and other anomalies much too small to be seen with older techniques can be detected.
9- X-rays cause damage to living tissues.
10- X-rays are used for destruction of cancer cells
11- X-rays can cause cancer
12- X-rays can cause changes in the productive system thus damages the organism's offspring.

UNVERTAINITY WITH IN ATOM

We can prove on the basis of Heisenberg equation that electrons cannot exist in nucleus.

i.e.

If electron is in nucleus

then

$\Delta x = 10^{-14}m$

so using equation

$\Delta p \geq h/\Delta x$ we find

$\Delta V = 7.3\times10^{10}$ m/sec

$\Delta V > C$ Which is not possible.

So we, can check the possibility for $\Delta x = 5\times10^{-11}$m (size of atom).

Repeating the same procedure we get

$V = 1.46\times10^{7}$ m/sec. Which is possible

Because $V < C$

So it shows that electron is **within atom** but not in nucleus. So we can conclude that electrons can only be found in the space in between atom and nucleus called shells.

LASER

Spontaneous and Stimulated Processes

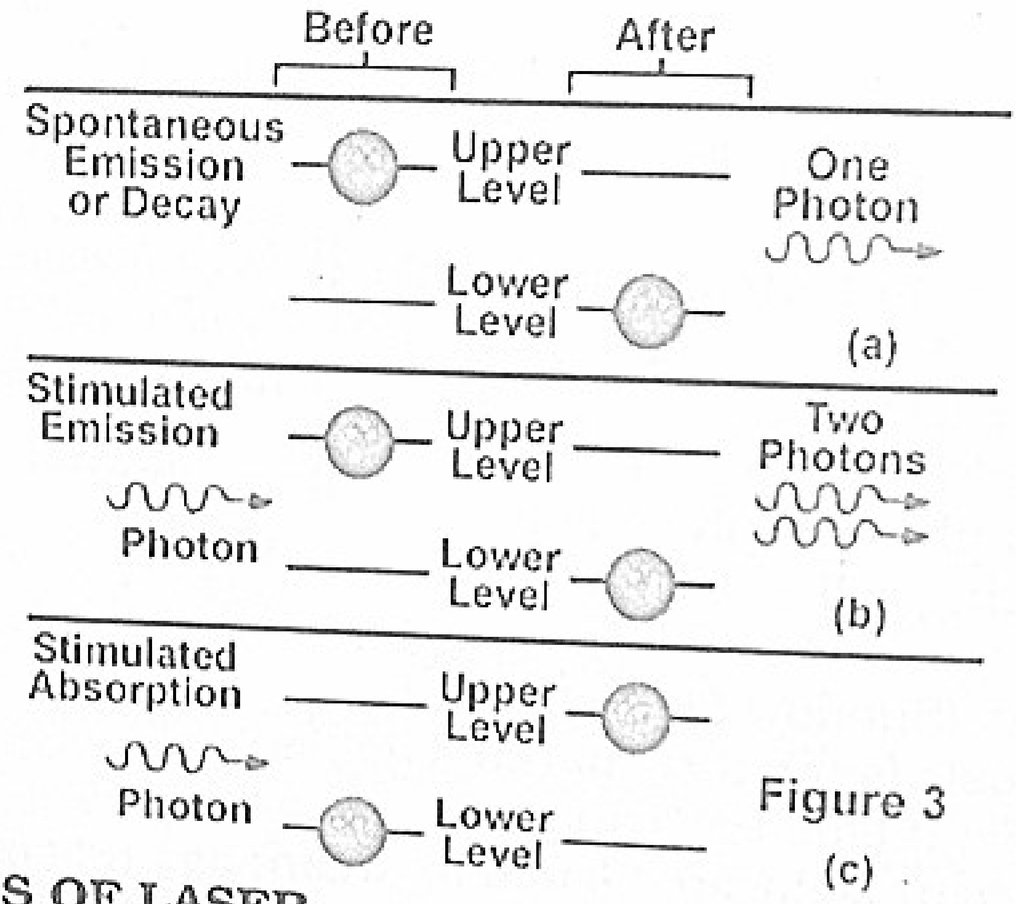


Figure 3

CHARACTERISTICS OF LASER

- Laser stands for ***light amplification by stimulated emission of radiation.***
- *Einstein developed theory of LASER* in 1917.
- LASER has following characteristics: -

1-	Monochromatic	2-	Unidirectional	3-	Coherent
4-	Sharply focused	5-	Highly polarized		

BASIC TERMS REGARDING LASER PRODUCTION

Metastable states: It is a high energy level in which electron can stay for long time (10^{-3} sec).

Optical pumping: It is process of providing energy to initiate and maintain the process.

Population inversion: The situation in which number of excited atoms exceeds the number of atoms in ground state.

Resonance: When stimulated photon passes by excited atoms, it stimulates it to radiate photon of same energy (by going to ground state) by the principle of resonance.

Stimulated emission: In stimulated emission the incident photo induces the atom to decay by emitting a photon that travels in the direction of the incident photon.

Coherence: It means that stimulated photons have same frequency and wavelength.

Do you know?

The laser beams actually eject out from a partially mirrored surface so that the reflected photon can further carry out the stimulated emission process

LASER UNIT

Important parts of LASER unit are as follows:

1-Cavity
2-Lasing material
3-Energy source.

TYPES OF LASER

Type of LASER	*Examples*
Solid laser	*Ruby laser, Semi-conductor laser*
Gas laser	*He-Ne laser, CO_2 laser*
Liquid laser	*Methanol + Die laser*

PROPERTIES OF LASER

1-Monochromatic
2-Coherency
3-Unidirectional
4-Reflection
5-Refraction
6-Diffraction
7-Polarization
8-Affect photographic plate
9-May damage (high energy laser) living tissues.

APPLICATIONS OF LASER

1-Laser as weapon (Laser-guided missiles)
2-Laser in industry (Drill tiny holes in steel & diamond)
3-Laser in research (Develop hidden finger prints)
4-Laser in medical treatment (Surgery of tumors, welding of retina, crush gall stones and kidney stones)
5-It is potential energy source for inducing fusion reactions.
6-Laser in holography (Hologram)
7- Holograms are three-dimensional images.

PRACTICE EXERCISE

30 mins Time Yourself!

(1) Band spectrum is produced by

(a)H
(b)H_2
(c)He
(d)Na

(2) Photon of highest frequency will be absorbed when transition takes place from ________

(a)1st to 5th orbit
(b)2nd to 5th orbit
(c)3rd to 5th orbit
(d)4th to 5th orbit

(3) Electrons held in the atom due to

(a)weak nuclear forces
(b)gravitational forces
(c)nuclear forces
(d)coulomb's forces

(4) If electron and proton have the same wavelength then they have same

(a)energy
(b)velocity
(c)momentum
(d)all of above

(5) Excited atoms return to their ground state in ____________

(a)10^{-10}s
(b)10^{-8}s
(c)10^{-6}s
(d)10^{-9}s

(6) If the mass of electron decreases by 30% then how will it effect Rydberg constant

(a)remain same
(b)become 1/8
(c)reduced by 70%
(d)become double

(7) Hydrogen atom does not emit X-rays because ____________

(a)its energy levels are too close to each other
(b)its energy levels are too far apart
(c)it is too small in size
(d)it has a single electron

(8) Which one of following postulate is in accordance with the Rutherford's model?

(a)continuous spectra for atoms
(b)discrete spectra for atoms
(c)either continuous nor discrete
(d)no spectrum

(9) X-rays are ____________

(a)of unknown nature
(b)high energy electrons
(c)high energy photons
(d)radio isotopes

(10) In excited state the total energy is E, what is K.E with proper sign

(a)2E
(b)-E/2
(c)2/E
(d)-E

(11) Ground state energy of the 4th orbit in a H-atom is ________

(a)–13.60 eV
(b)–3.40eV
(c)–0.85eV
(d)–1.51eV

(12) Total number of series in hydrogen spectrum is ____________

(a)three
(b)four
(c)five
(d)six

(13) The radiations emitted form hydrogen filled discharge tube show______

(a)band spectrum
(b)line spectrum
(c)continuous spectrum
(d)absorption spectrum

(14) The electric P.E of an electron in an orbit at a distance r_n from the positive charge ________

(a)Ke^2/r_n
(b)Ke^2/r_n^2
(c)$-Ke^2/r_n$
(d)$-Ke^2/r_n^2$

(15) Radiation with wavelength longer than red lights ________

(a)ultraviolet rays
(b)X-rays
(c)infra red radiation
(d)visible radiation

(16) Bracket series is obtained when all transition of electron terminate on ________

(a)4th orbit
(b)5th orbit
(c)3rd orbit
(d)2nd orbit

(17) In an electronic transition, atom cannot emit ________

(a)γ-rays
(b)infra red radiation
(c)visible light
(d)ultraviolet rays

(18) Reverse process of photoelectric effect is ________.

(a)pair production
(b)Compton effect
(c)annihilation of matter
(d)X- rays production

(19) X rays are similar in nature to ________

(a)cathode rays
(b)positive rays
(c)γ- rays
(d)α- rays

(20) The penetrating power of X- rays depends on their ________

(a)applied voltage
(b)Filament current
(c)source
(d)all of the above

(21) A Balmer line is emitted when the electron in a hydrogen atom jumps from

(a)a higher orbit to the first orbit
(b)a higher orbit to the second orbit
(c)the first orbit to a higher orbit
(d)the second orbit to a higher orbit

(22) The penetrating power of X- rays is comparable with that of______

(a)α- rays
(b)β-rays
(c)γ-rays
(d)all of above

(23) If the charge on electron and proton become double then Rydberg constant will be

(a)R/2
(b)8R
(c)R/8
(d)2R

(24) Radiation produced from TV picture tube is________

(a) γ-rays.
(b) X-rays.
(c) Far infrared.
(d) Infrared.

(25) In an X-ray tube, electrons each of charge e are accelerated through V potential difference allowed to hit a metal target. The wavelength of the X-rays emitted is________

(a) hc/eV
(b) he/Vc
(c) eV/h
(d) impossible to predict

(26) The minimum wavelength of X-rays can further be reduced by______

(a) Reducing the pressure or cooling the target.
(b) Increasing the temperature of the filament.
(c) Using a target element of higher atomic number.
(d) Increasing the potential difference between the cathode and the target.

(27) The characteristic X-rays spectrum is due to ______

(a) The illumination of the target metal by ultra-violet radiation.
(b) The bombardment of the target by protons.
(c) The bombardment of target by electrons.
(d) The absorption of γ radiation by the target metal.

(28) The minimum wavelength of X-rays produced by the bombardment of electrons on the screen of a television set where the accelerating potential is 2.0K V, will be ______

(a) 6.2×10^{-10}m. (b) 9.1×10^{-18}m.
(c) 3.11×10^{-10}m. (d) 4×10^{-10}m.

(29) Maximum frequency in the spectrum from X-ray tube is directly proportional to the ______

(a) Number of incident electron i.e. filament current.
(b) The kinetic energy of the incident electron i.e. the potential difference through which they are accelerated.
(c) The soft target which can easily emit electrons.
(d) all of above are correct.

(30) X-rays are diffracted by a crystal but not by a diffraction grating because ______

(a) The ions in a crystal are well arranged.
(b) The lines in a diffraction grating cannot reflect X-rays.
(c) The penetration power of X-rays is high in a diffraction grating.
(d) The wavelengths of X-rays are of the same order of magnitude as the separation between atoms in a crystal.

(31) UV radiation can be produced by ______

(a) Heating the filament. (b) Electron excitation in the gas.
(c) Ionization of atoms. (d) All the above.

(32) What is the velocity of a particle of mass m & de-Broglie wavelength λ?

(a) $h/m\lambda$ (b) $2h/m\lambda$
(c) mh/h (d) $(2hc/m\lambda)^{1/2}$

(33) Wave-like characteristic of electron is demonstrated by ______

(a) Line spectrum of atoms.
(b) Production of x-rays.
(c) Diffraction by crystalline solids.
(d) Photoelectric effect.

(34) Electron cannot exist in the nucleus; it is confirmed by observing that ______

(a) It does emit γ-radiation.
(b) Its size as compare to proton and neutron is very small.
(c) No antiparticle of electron is present.
(d) The velocity of electron must by very high according to uncertainty principle.

(35) In normal state of energy, the incident high energy photons will be ______

(a) Stimulated. (b) Absorbed.
(c) Cause X-ray emission. (d) Cause laser production.

(36) In laser production, the state in which more atoms are in the upper state than in the lower one is called ______

(a) Metal stable state. (b) Normal state.
(c) Inverted population. (d) All the above.

(37) The metastable state for an atom in laser light is______

(a) 10^{-4}sec.
(b) 10^{-5}sec.
(c) 10^{-3}sec.
(d) 10^{-8}sec.

(38) In He-Ne laser, the lasing action is produced by______

(a) Ne only.
(b) He-Ne both.
(c) Electrons of He.
(d) Electrons of Ne.

(39) Reflecting mirrors in laser is used to ______

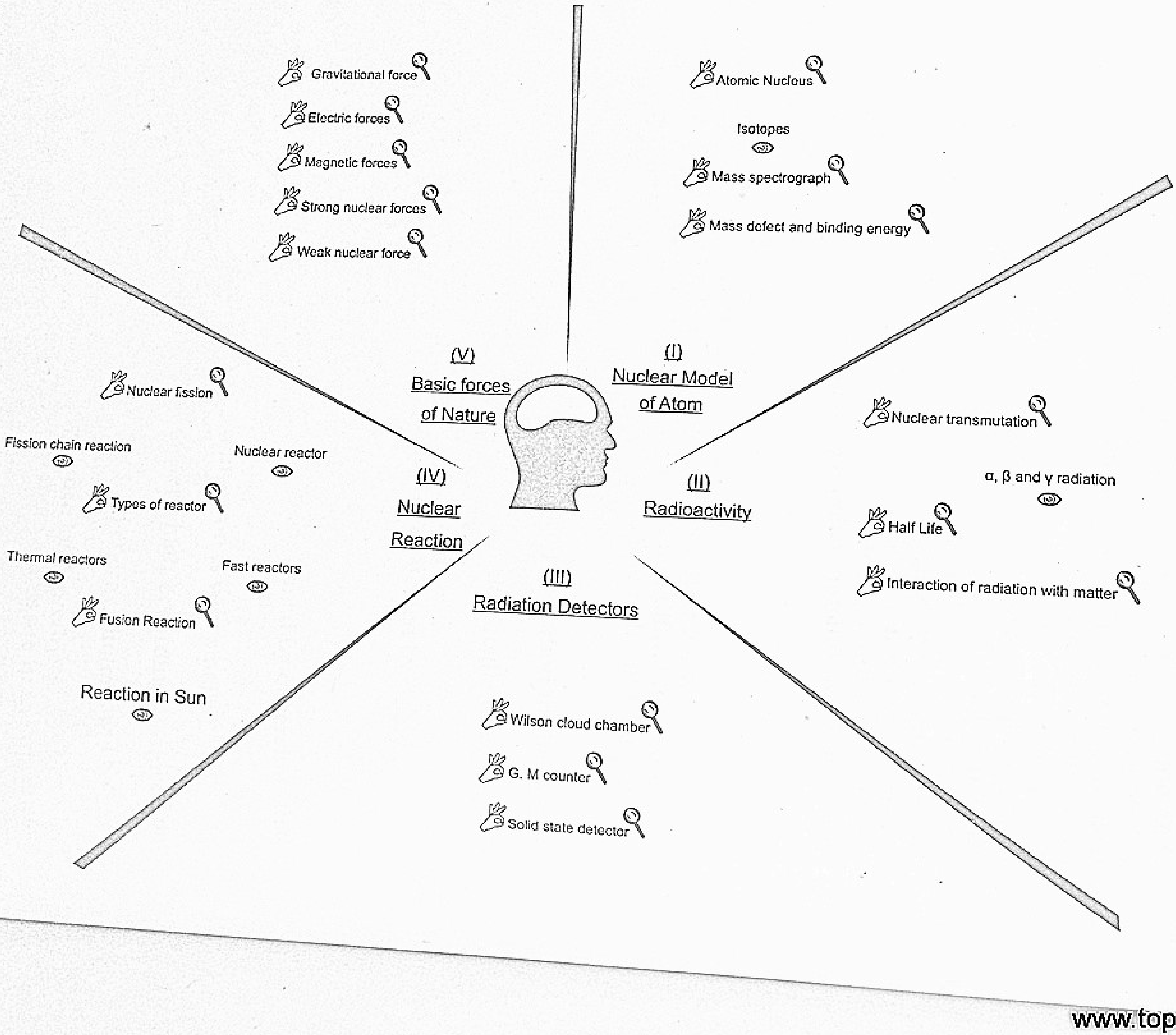
(a) Further stimulation.
(b) Lasing more.
(c) For producing more energetic lasers.
(d) All the above.

(40) The velocity of laser light is ______

(a) Less than ordinary light.
(b) More than ordinary light.
(c) Equal to ordinary light.
(d) Different for different colours or frequency.

Chapter 21

NUCLEAR PHYSICS



(I) Nuclear Model of Atom

- Atomic Nucleus
- Isotopes
- Mass spectrograph
- Mass defect and binding energy

(II) Radioactivity

- Nuclear transmutation
- α, β and γ radiation
- Half Life
- Interaction of radiation with matter

(III) Radiation Detectors

- Wilson cloud chamber
- G. M counter
- Solid state detector

(IV) Nuclear Reaction

- Nuclear fission
- Fission chain reaction
- Nuclear reactor
- Types of reactor
- Thermal reactors
- Fast reactors
- Fusion Reaction
- Reaction in Sun

(V) Basic forces of Nature

- Gravitational force
- Electric forces
- Magnetic forces
- Strong nuclear forces
- Weak nuclear force

J.J. THOMSON'S MODEL OF ATOM

Postulates

1- Atom is a neutral material in which negative electrons are embedded on positive nucleus.
2- Density of atom is **uniform.**
3- There is no empty place in the atom.

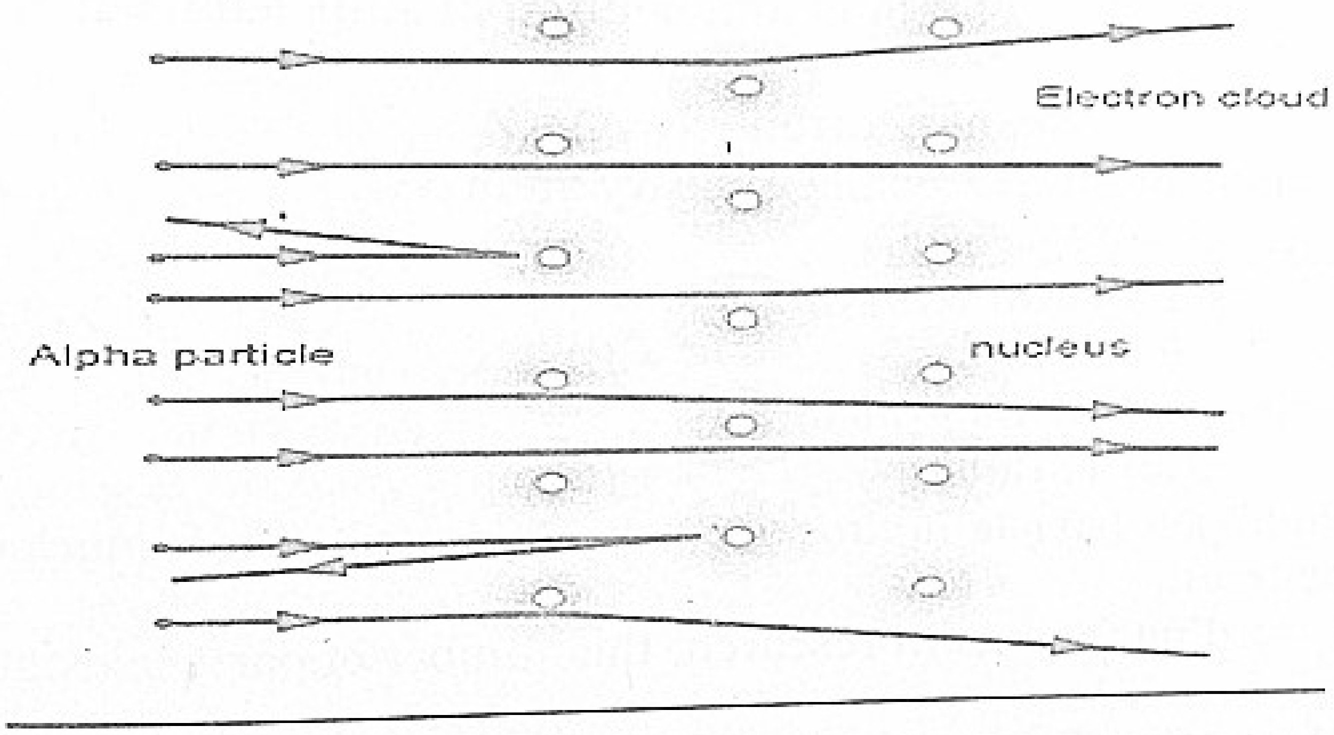
Objections

4- There is no static equilibrium between electron and positive charge.
5- Density of atom is **not uniform.**

RUTHERFORD'S ATOMIC MODEL

Postulates

1- Most of the part of atom is empty.
2- Central part is tiny and positively charged. It is called **nucleus.**
3- Electrons are revolving about nucleus in **circular orbits.**
4- Almost whole of mass is **concentrated** in nucleus (i.e. atom has non-uniform density).



Objections

1- The revolving electrons if moving **continuously**, will emit energy **continuously**.
2- If energy is emitted continuously, then spectrum should be **continuous** but a line **spectrum** is obtained.
3- If energy is emitted continuously, then atomic assembly will collapse

BOHR'S ATOMIC MODEL

Postulates

1- Electron can revolve only in those orbits in which its angular momentum is integral multiple of n h/2π.

$$mVr = nh/2\pi$$

Such orbits are called ***allowed orbits*** or *stationary state or Bohr's orbits.*

2- As long as an electron remains revolving in its allowed orbit, the energy of electron remains **constant.**

3- When electron jumps down between two allowed orbits, it radiates energy in the form of photon of energy as given below.

$$\Delta E = E_2 - E_1 = hf$$

Objections

1- Electronic orbits are not **circular**.
2- Fine structure of atomic spectra could not be explained.
3- Effect of nuclear motion on atomic spectra is not made **clear.**

NUCLEUS & ITS COMPOSITION

- Nucleus is a tiny region in which almost all mass of atom is **confined.**
- Rutherford thought that whether nucleus is a lump of mass or it is an **aggregate** of particles.
- Size of atom is **10^{-10}m** and that of nucleus is **10^{-14}m.**
- According to Rutherford's findings, nucleus is composed of neutron and **proton, collectively known as nucleons**, symbolized as:

$$_ZX^A$$

where Z = no. of electrons or protons in neutral atom = charge no.
A = sum of proton and neutron in a nucleus = mass no.
So,

$$\text{No. of neutron} = N = A - Z$$

- In small atom N=Z, while in heavy atom N>Z.
- *Discovery of Nucleons*
  1- Proton (by Rutherford)

$$_2He^4 + {}_7N^{14} \rightarrow {}_8O^{17} + H^1$$

  2- Neutron (by Chadwick)

$$_2He^4 + {}_4Be^9 \rightarrow {}_6O^{12} + {}_0n^1$$

- *Hydrogen (simple hydrogen) is the only atom whose nucleus contains no* ***neutron.***
- According to modern research, the number of particle existing in nucleus is 37.
- Mass of nucleus is roughly equal to sum of masses of nucleons.
- *Unit of mass at atomic level is a.m.u.*

$$\mathbf{1\ a.m.u = 1.66 \times 10^{-27}\ kg}$$

- Masses of some well-known particles on a.m.u scale are given below:

Particle	*Symbol*	*Mass (in a.m.u)*
Electron	$_{-1}e^0$	*0.00055 a.m.u*
Proton	$_1H^1$	*1.007276 a.m.u*
Neutron	$_0n^1$	*1.008665 a.m.u*
Deuteron	$_1H^2$	*2.014102 a.m.u*
Helium nucleus	$_2H^4$	*4.002603 a.m.u*

For your information

We can calculate number of neutrons in a nucleus by simply subtracting mass number and atomic number i.e. $_{92}U^{235} \rightarrow 235 - 92 = 143$
So this nucleus contains 143 neutrons.

- **1.a.m.u = 931 MeV** ⇒ 1.66×10^{-27} kg = 931 MeV

Isotopes

"Isotopes are such nuclei of an element having the same atomic number but different mass number."

- Isotopes have same number of protons.
- They have different number of neutrons.
- Isotopes of an element have the same **chemical** but different **physical** properties.

MASS SPECTROGRAPH

Mass spectrograph is an electromagnetic instrument used for the measurement of ***masses*** *of isotopes.*

- *Principle of mass spectrograph*

$$r \propto \sqrt{m}$$

- *Radius of path* described by charged ion in mass-spectrometer is given as;

$$r = \sqrt{2Vm/B^2q}$$

Where V = potential difference

q = charge

B = magnetic field

- Mass spectrograph sorts out positive ions
- Centripetal forces of the magnetic field provide the isotopes a suitable radius to bend about.

NUCLEAR FORCES

- Nucleus contains protons that repel each other, may cause the destruction of **nucleus.**
- There are two *classical forces*, operating in nucleus.

1- Coulomb's repulsive force;

$$F_e = K e^2/r^2$$

2- Newton's attraction force;

$$F_g = G m^2/r^2$$

- Classical forces are unable to give stability to the nucleus because;
- Due to strong repulsive forces in nucleus, it requires much energy for the entry of another charged particles e.g. proton.

Example: 7.2 MeV energy is required to the addition of 1 proton into a nucleus of 50 **protons**

- Force, which has binding effect on nucleons to give stability of nucleus, is called ***strong nuclear force.***
- ***Properties of strong nuclear force***
  1- It does not obey inverse square law.
  2- It is the strongest force having range equal to nuclear diameter 10^{-14}m.
  3- It is always attractive force and has binding effect inside the nucleus.
  4- Strong nuclear force is attraction only within nucleus while a strong repulsion outside the nucleus because of coulomb's **repulsive force.**

MASS DEFECT

*Mass defect is the difference between mass of **nucleus** and sum of masses of its **nucleons**.*

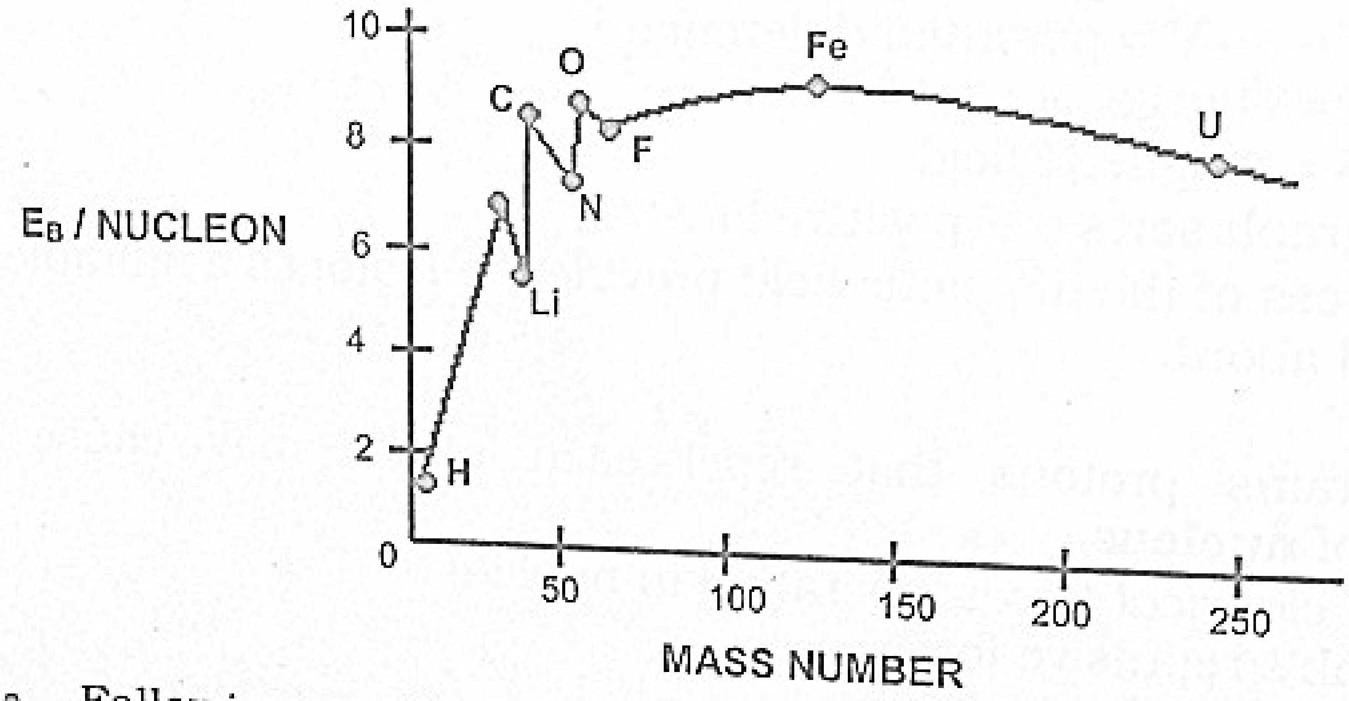
Δm = sum of masses of nucleons – mass of nucleus

e.g. for deuterium ($_1H^2$), $\Delta m = 0.002388$ a.m.u

- Mass defect Δm is converted into energy Δmc^2 called ***binding energy***. It is liberated in the form of photon.

$$E = \Delta m \times 931 MeV = [(Z\,m_p - N\,m_n) - m] \times 931 MeV$$

- After liberation of binding energy ($E = \Delta\ mc^2$), the nucleus becomes stable e.g. B.E for deuterium is **2.24 MeV.**
- When energy equal to binding energy is provided to nucleus, somehow, the nucleus dissociates into nucleons.
- Binding energy can be given as energy required to dissociate nucleus into **nucleons.**
- Graph between mass number (A) and B.E per nucleon is shown below:



- Following conclusions can be drawn from above curve:

1- Binding energy of a light atom is very large, that is why they are stable (maximum value is at A=56).

2- Binding energy per nucleon for heavy atoms is smaller, that is why they are less stable.

3- Binding energy (B.E) increases with increasing A. B.E decreases with increase in A if Z > 82.

4- the binding energy per nucleon is maximum for iron.

- $\Delta m/A$ is called ***packing fraction***

RADIOACTIVITY

- Becquerel discovered **radioactivity.**
- Nuclei having Z > 82 are unstable and they emit α, β and γ rays; the phenomenon is called ***radioactivity.***
- Some radioactive elements are Po (Z=84) Rd (Z=88) and U (Z=92) etc.
- ***α-decay***

Charge no. (Z) decreases by 2 and mass no. (A) by 4

$$_ZX^A \longrightarrow {}_{Z-2}Y^{A-4} + {}_2He^4 + Q$$

e.g.

$$_{92}U^{238} \longrightarrow {}_{90}Th^{234} + {}_{2}He^{4} + 4.3Mev.$$

- ***β-particle***

β-particle is electron or positron coming from nucleus. So it may be classified as;

1- *β^{-} decay*

$$_{z}X^{A} \longrightarrow {}_{z+1}Y^{A} + {}_{-1}e^{o} + \upsilon +$$

Only charge no. (Z) **increases by 1.**

Its prototype is decay of neutron itself that changes to p and $_{-1}e^{o}$.

$$^{1}_{0}n \longrightarrow {}^{1}_{1}p + {}_{-1}e^{o} + \bar{\upsilon}$$

e.g.

$$_{11}Na^{24} \longrightarrow {}_{12}Mg^{24} + {}_{-1}e^{o} + \bar{\upsilon}$$

2- *β^{+}-decay*

$$_{z}X^{A} \longrightarrow {}_{z-1}X^{A} + {}_{+1}e^{o} + \bar{\upsilon}$$

Only charge no. (Z) **decreases by 1.**

Its prototype is decay of proton itself that changes to n and $_{-1}e^{o}$.

$$^{1}_{1}p \longrightarrow {}^{1}_{0}n + {}_{+1}e^{o} + \upsilon$$

e.g.

$$_{9}F^{17} \longrightarrow {}_{8}O^{17} + {}_{+}e^{o} + \upsilon$$

NOTE: Weak interaction only appears in β-decay.

- ***γ-decay***

γ-decay is due to de-excitation of nucleus.

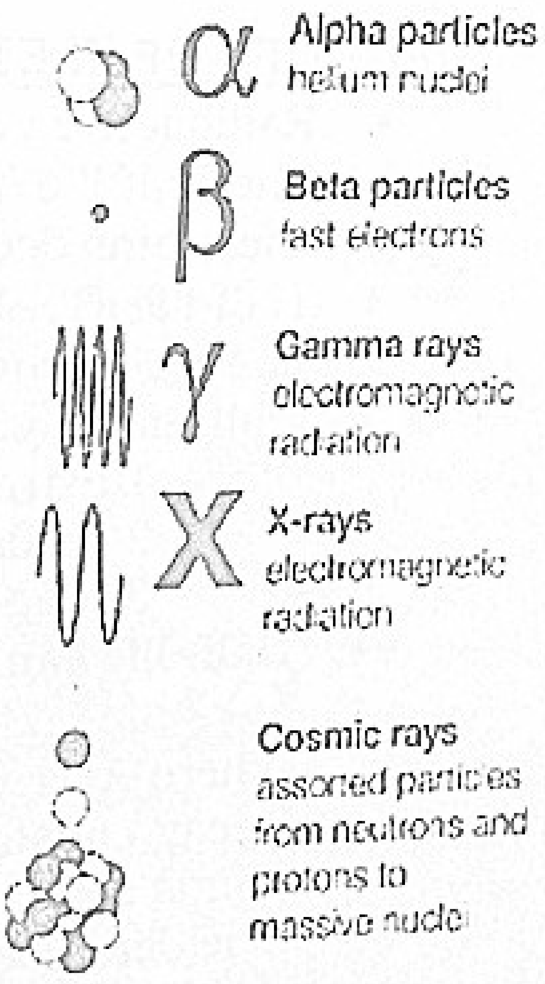
e.g. zX^{A*} $zX^{A}+\gamma$, * show **excitation of** atom

$$_{38}{}^{*}Sr^{87} \longrightarrow {}_{38}S\gamma^{87} + \gamma -$$

photon

$$_{12}Mg^{27} \longrightarrow {}_{13}{}^{*}Al^{27} + {}_{-1}\beta^{o} + V$$

$$_{13}{}^{*}Al^{27} \longrightarrow {}_{13}Al^{27} + \gamma\text{-photon}$$



Type of Radiation	Alpha particle	Beta particle	Gamma ray
Symbol	α or $^{4}_{2}\alpha$ or $^{4}_{2}He$	β or β^{-}	γ (can look different, depends on the font)
Mass *(atomic mass units)*	4	1/2000	0
Charge	+2	-1	0
Speed	slow	fast	very fast (speed of light)
Ionizing ability	high	medium	0
Penetrating power	low	medium	high
Stopped by:	paper	aluminium	lead

HALF-LIFE OF ELEMENTS

- Radioactive decay is a random process so we get idea of **half-life.**
- The half-life $T_{1/2}$ of a radioactive element is that period in which half of the atoms decay.
- Half-life ($T_{1/2}$) depends on element and is not affected by any physical change or chemical change.
- Half-life may be classified as follows:
  - 1-extremely short half-life: $T_{1/2}$ in micro or nano seconds
  - 2-moderate half-life: $T_{1/2}$ in minutes.
  - 3-long half-life: $T_{1/2}$ in years.
- Half- life can be given as:

$$T_{1/2} = 0.693/\lambda.$$

Where λ is called ***decay constant*** depends upon nature of material. Decay constant of any element is equal to the fraction of the decaying atoms per unit time. The unit of the decay constant is s^{-1}.

- The decay curve shows that radioactive element decay exponently
- *Half-life is used to identify an atom.*

LAWS OF RADIOACTIVITY

- $\Delta N / \Delta t \quad \alpha \quad N_o$
- $\Delta N / \Delta t = -\lambda N_o$
- $N_t = e^{-\lambda t} N_o$
- $T_{1/2} \quad \alpha \quad 1/\lambda$
- $\lambda = \dfrac{-\Delta N / \Delta t}{N}$
- Mean life = $T = 1/\lambda$

Do you know?

The No. of atoms left after a set of radioactive decays say "n" can be calculated using formula
Atom left = $N_o/2^n$ *Where*
N_o *= original no of atoms*
n *= no of half lives.*

INTERACTION OF RADIATION WITH MATTER

α, β & γ rays are called nuclear radiations.

- Interaction of nuclear radiations with matter depends on three characteristics of nuclear radiations.

1- Mass of particle
2- Charge of particle
3- Energy of particle and
4- Density of the medium
5- Ionization potentials of the atoms of the medium

INTERACTION OF α-RAYS

- α-particle can do ionization in following two ways.
  1- Mechanical collision (α- particle directly hits electron)
  2- Coulomb's interaction (electrostatic interaction)
- Mode of ionization by Coulomb's interaction (electrostatic attraction) for α-rays dominates over that by direct collision.
- *The path of ionization followed by α-rays is straight and continuous* because of its high **ionization power and large mass.**
- During ionization, α-particle continuously looses its energy as a result of which its velocity decreases.
- In each collision, α-particle loses an average of 35eV energy.
- 7.7 MeV α-particle produces $2\text{x}10^5$ ion pairs before stopping.
- When α-particle has spent all its energy on ionization, it absorbs two electrons from its surroundings gas and becomes a neutral (He atom).
- Range of α-particle in air is small due to intense ionization.
- 7.7 MeV α-particle has 7cm range in air at S.T.P, which reduces further in denser medium.
- Range of 7.7Mev α-particle in aluminum is only 0.04 mm.
- α-particle produces disintegration in nuclei of some atoms if they have high energy.

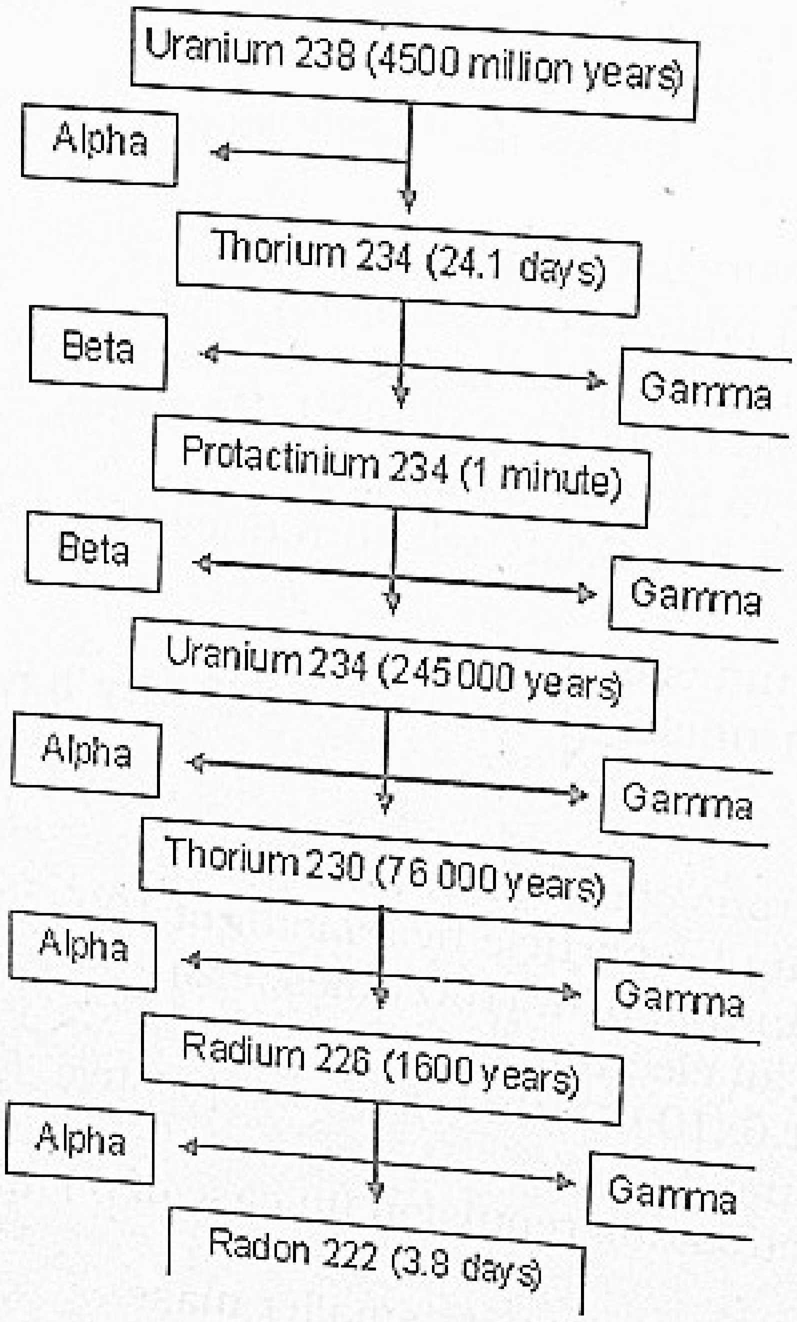
INTERACTION OF β-RAYS

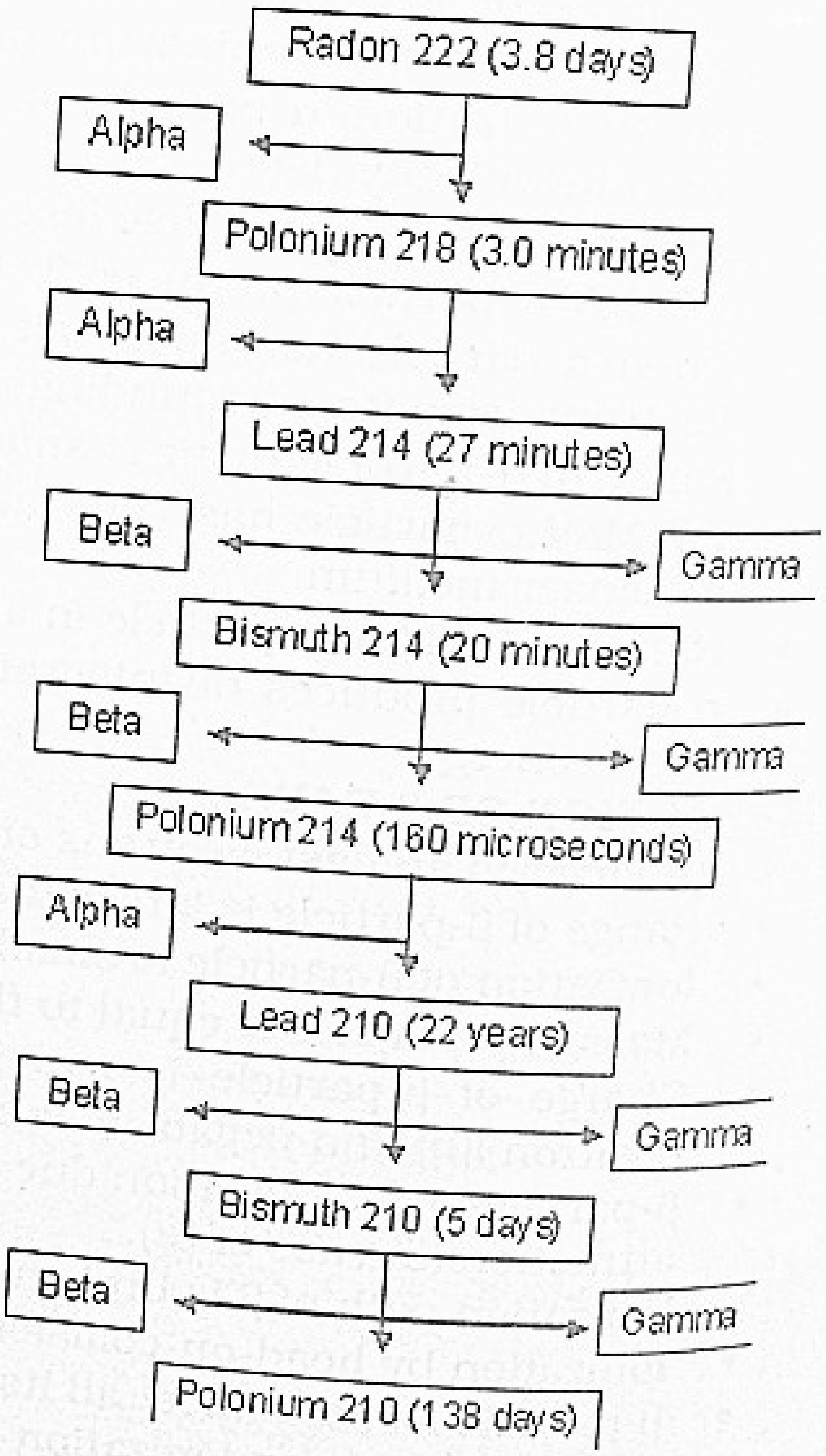
- β-particles are fast electrons or positrons coming from nucleus.
- Range of β-particle is larger than that of α-particle by a factor of 100.
- Ionization of β-particle is smaller than that of α. (100 times less)
- Mass of β-particle is equal to that of an electron.
- Charge of β-particle is equal to $1.6\text{x}10^{-19}$C that may be positive for positron (β^+) and negative for electron (β^-).
- β-particle does ionization due to electrostatic repulsion (in case of β^-) and attraction (in case of β^+).
- Ionization path of β is broken and **zigzag due to its** smaller mass.
- Ionization by head-on-collision is very rare.
- β-particle looses almost all its energy in a single encounter.
- Because of lesser ionization encounters, penetration of β is 100 times larger than that of α-particle of same energy.
- 3 MeV β-particle can pass through 6.5mm aluminum foil.
- β-particle can produce fluorescence.

INTERACTION OF γ-RAYS

- γ-rays being photons can't be stopped by matter (lead can be used as a shield because of its high electron density).
- γ-rays have shorter wavelength than X-rays.
- γ-particles loose their energy by following three ways.
  1- Compton effect
  2- Photoelectric effect
  3- Pair production.
- The type of interaction depends upon energy range of photon available according to following scheme:

Energy Range	*Type of Interaction*
E < 0.1 MeV	*Photoelectric effect*
E = 0.1Mev to 1MeV	*Compton effect*
E > 1.02 MeV	*Pair production*

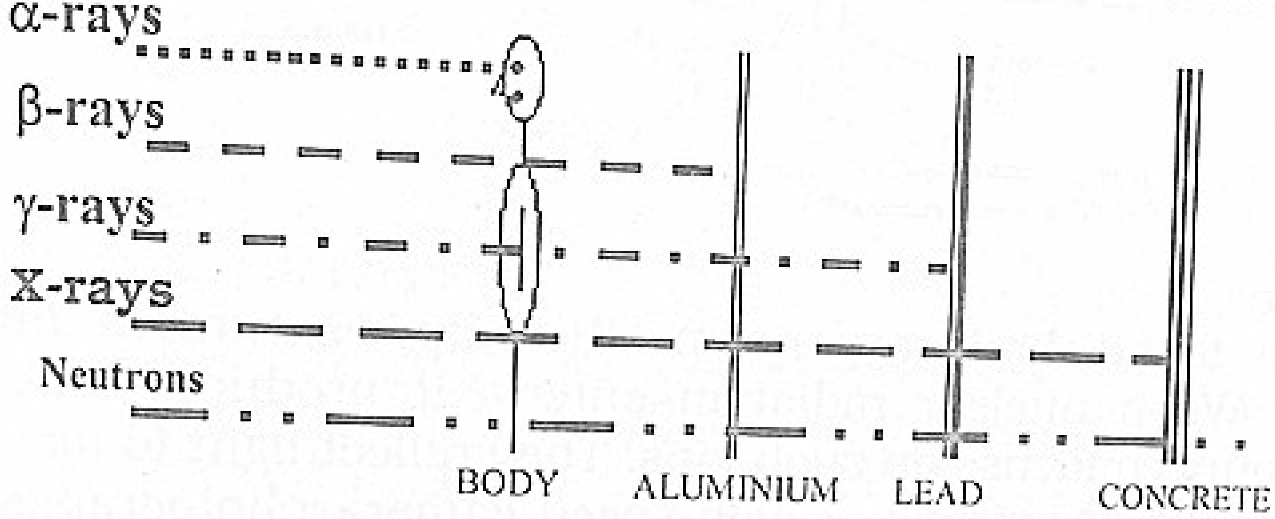




INTERACTION OF NEUTRONS

- Neutrons are more effective radiation than both α and β rays because they bear no charge as **regard to penetration.**
- When neutron is captured by a nucleus, it results in the formation of a **radioisotope.**
- Neutron causes fission in heavy nuclei.
- Neutron can knock down electrons out of body cells causing **instantaneous death.**

COMPARISON OF PENETRATION POWER OF VARIOUS RADIATIONS

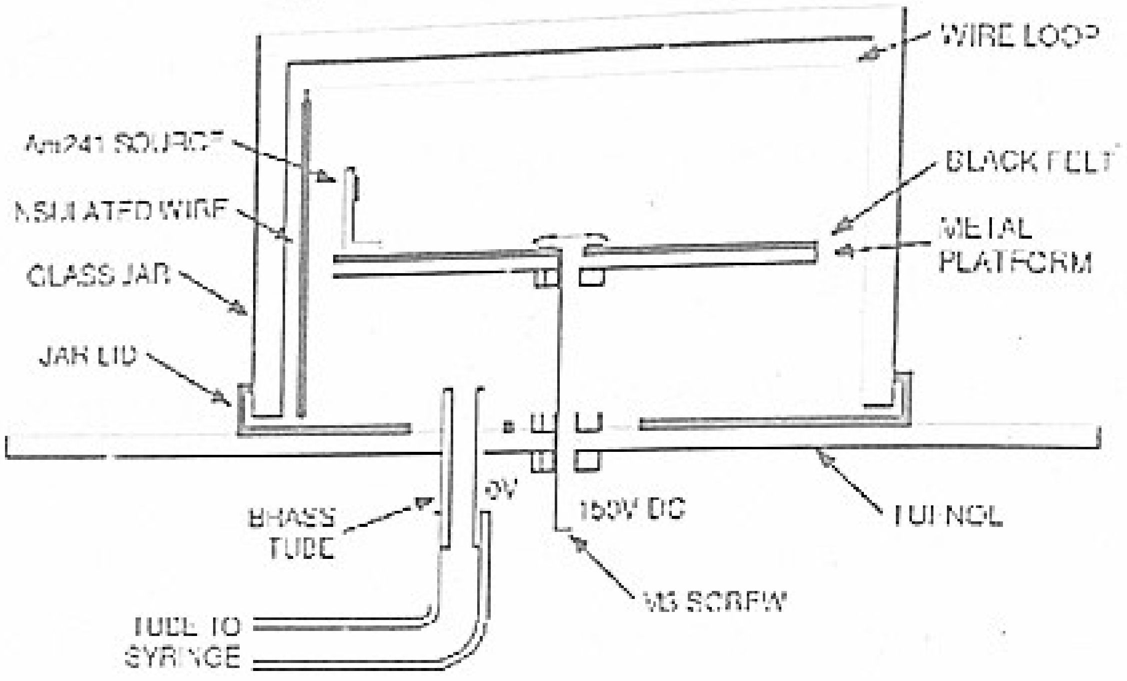


Radiation	*Description*	*Penetration*	*Ionization*	*Effect of E or B field*
Alpha (α)	Helium nucleus 2p + 2n Q = +2 *e*	Few cm air Thin paper	Intense, about 10^4 ion pairs per mm.	Slight deflection as a positive charge
Beta (β)	High speed electron Q = -1 *e*	Few mm of aluminium	Less intense than a, about 10^2 ion pairs per mm.	Strong deflection in opposite direction to a.
Gamma (γ)	Very short wavelength em radiation	Several cm lead, couple of m of concrete	Weak interaction about 1 ion pair per mm.	No effect

WILSON CLOUD CHAMBER

- C.T.R Wilson in 1911 invented Wilson cloud chamber.
- Wilson cloud chamber is based upon the following principle: -
  "Super saturated droplets prefer to condense on ions or dust particles similar to formation of clouds."
- **Construction**

It consists of a circular base metal plate with hole in the center. Above it, is another metal plate with a black felt pad. A perspex or glass dome fits over the two plates with the source on its top.

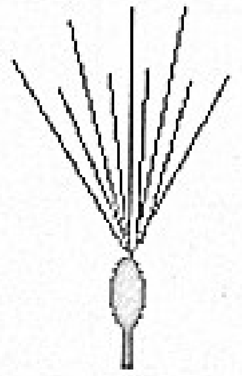


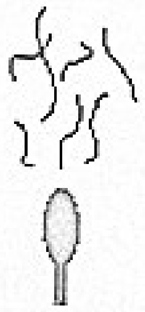
- *Procedure*

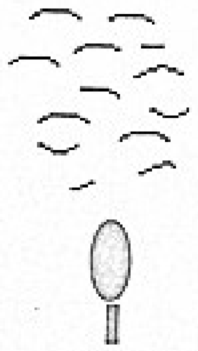
  Due to adiabatic expansion, the super-saturated droplets are produced. When nuclear radiation enters, it produces ionization and water vapours condense on such ions. They reflect light to make the path of ionizing particles visible. A high-speed camera photographs the track of ionizing particle.

- *Track of Ionizing Particle*

Name of Particle	*Shape of Track*
α-particle	*Solid and continuous*
β-particle	*Zigzag and discontinuous*
γ-particle	*No definite track*


α-rays


β-rays

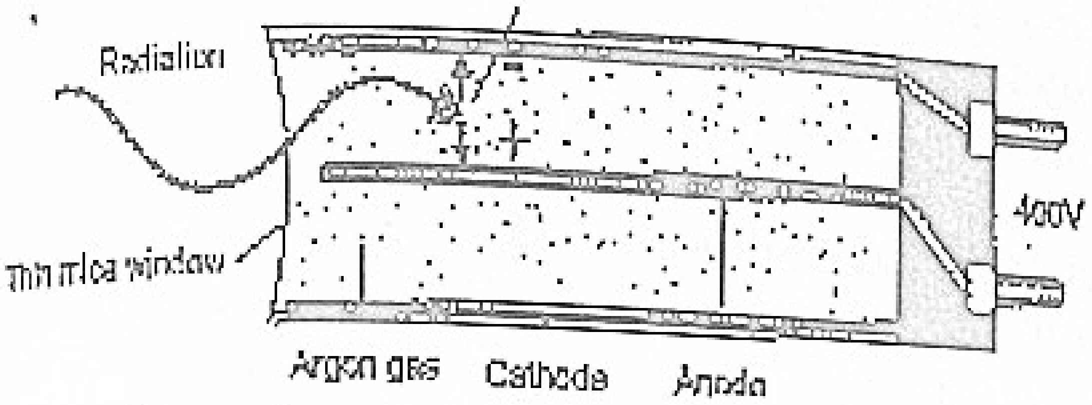

γ-rays

- By applying magnetic field, the α & β particles deviate from its original path.
- By measuring radii of curvature, we can also measure e/m ratio of α & β particles.
- Length of cloud tracks is proportional to energy

GEIGER - MULLER COUNTER

- Geiger and Muller invented G.M counter (Geiger - Muller counter).
- Construction

G.M counter consists of a metal tube (cathode) containing inert gas (such as argon & alcohol or bromine and neon) at 0.1 atmospheric pressure. There is a thin wire (anode) co-axial with metallic tube.



The Geiger Mueller counter is an electronic instrument used for detecting and measuring low level β-particle and γ-ray radiation. It cannot detect α-particles. It is also known as a G-M Counter.

- *Procedure*

  1- When nuclear radiation enters, it produces ionization in halogen gas ions.

  2- **Positive ions move** towards negative metallic plate while negative ions **towards positive** wire.

  3- Electrons released by nuclear radiation rush towards the positive wire knocking out electrons from atoms of gas in their way. In this way an **avalanche** of electrons reach the wire and hence current pulse is produced.

  4- The current pulse is detected across a **resistance of $10^9\Omega$.**

- ***Quenching of Discharge***

  Positive ions on reaching the metal tube pull out electrons. These electrons can excite the atoms, which on returning to ground state emit photons, which then ejects **photoelectrons under photoelectric effect.** To avoid photoelectrons, we do quenching.

  Quenching of discharge in G.M counter is attained by following two ways:

  1- *Manual quenching:* by lowering voltage below critical value of discharge.

  2- *Self-quenching:* by adding bromine gas into principal gas (neon). The mechanism is such that the I:E of bromine is lower than neon, the ions of quenching gas reach the cathode before principal gas ions. When they reach near the cathode, they capture electron and become neutral molecules. Following neutralization, the excess energy of the quenching molecules is dissipated in dissociation of the molecules rather than in the release of electrons from the cathode.

- G.M counter can be used to study β and γ-rays effectively.

SOLID STATE DETECTOR

- Solid State detector is most sensitive **detector capable of detecting** three α, β & γ-rays.

- *Construction*

  Solid State detector mainly consists of reverse biased diode.

- *Procedure*

  When radiation falls on the diode, it causes the release of electrons, creating some sort of conduction path. The voltage caused due to flow of electrons is measured.

- *Advantages*
  1- Compact size
  2- Very fast detector
  3- No need of quenching
  4- Portable
  5- Can detected α, β and γ-rays.

6- Low energy utilization (requires 3eV — 4eV of energy

NUCLEAR FISSION

- *Otto Hahn* and his co-workers discovered nuclear fission accidentally when they were attempting to prepare transuranic elements by bombarding ${}_{92}U^{235}$ with ${}_0n^1$ (slow).
- ***Transuranic*** *elements* are those elements that have atomic no. greater than that of uranium (the heaviest natural element) e.g. Np (Z=93), Pu (Z=94) etc.
- There are 30 different ways by which nucleus can undergo **fission** accompanied by 2 to 5 neutrons (average is 2.5 neutrons).
- *Fission neutrons are ejected by* ***daughter or fission fragment****, not by parent nucleus.*
- During fission, 9' in extremely short time and are called prompt neutrons; the remaining 1% are emitted a litter latter. They are called ***delayed neutrons.***
- Unstable fission fragments, to become stable, eject delayed neutrons.
- ***Isotopes of Uranium***

Ore	*Percentage*	*Half-life*
${}_{92}U^{238}$	*99.38%*	*4.51 x 10⁹years*
${}_{92}U^{235}$	*0.714%*	*7.1 x 10⁸years*
${}_{92}U^{234}$	*0.006%*	*2.48 x 10⁵years*

- For fission of ${}_{92}U^{238}$, ${}_0n^1$ of energy 1 MeV is required while for ${}_{92}U^{235}$, ${}_0n^1$ of energy 0.04 eV is required.
- Two common fission reactions for uranium are as follows:

$${}_0n^1+{}_{92}U^{235} \rightarrow {}_{56}Ba^{141}+{}_{36}Kr^{92} + 3\,{}_0n^1 + 200 \text{ MeV } (Q)$$

$${}_0n^1+{}_{92}U^{235} \rightarrow {}_{54}Xe^{140} + {}_{38}Sr^{94} + 2\,{}_0n^1 + 200 \text{ MeV}$$

where Q is called energy of nuclear reaction.

- TNT **(trinitrotoluene)** is an explosive material whose one molecule explodes by giving 30eV energy. Atomic fission in said to be of power equal to explosion of **1000 kilogram of TNT**.

TYPES OF FISSION

i) Controlled fission chain reaction.

In this reaction only one neutron, out of all the neutrons created in one fission reaction, becomes the cause of further fission reaction. It is the underlying principal of nuclear reactor.

ii) Critical mass

Such a mass of uranium in which one neutron, out of all the neutrons produced in one fission reaction, produces further fission is called critical mass.

iii) Uncontrolled fission chain reaction

If the mass of uranium is much greater than the critical mass, then the chain reaction proceeds at a rapid speed and a huge explosion is produced. Atom bomb works at this principal

- *Fermi carried out first **controlled fission** in 1942.*
- Fission of $_{92}U^{235}$ atom releases 10^8 times as much energy as is released by $_6C^{12}$ atom in ordinary furnace.

1 kg of $_{92}U^{235}$ contains⇒ $6.023x10^{26}/235 = 25x10^{23}$ atoms

We know that,

1atom of $_{92}U^{235}$ gives ⇒ 200 MeV

∴ 1kg of $_{92}U^{235}$ gives ⇒ $5 x 10^{26}$MeV

We know that,

Time for one fission ⇒10^{-8} sec

∴ Time for 60 fissions ⇒ 0.6μs

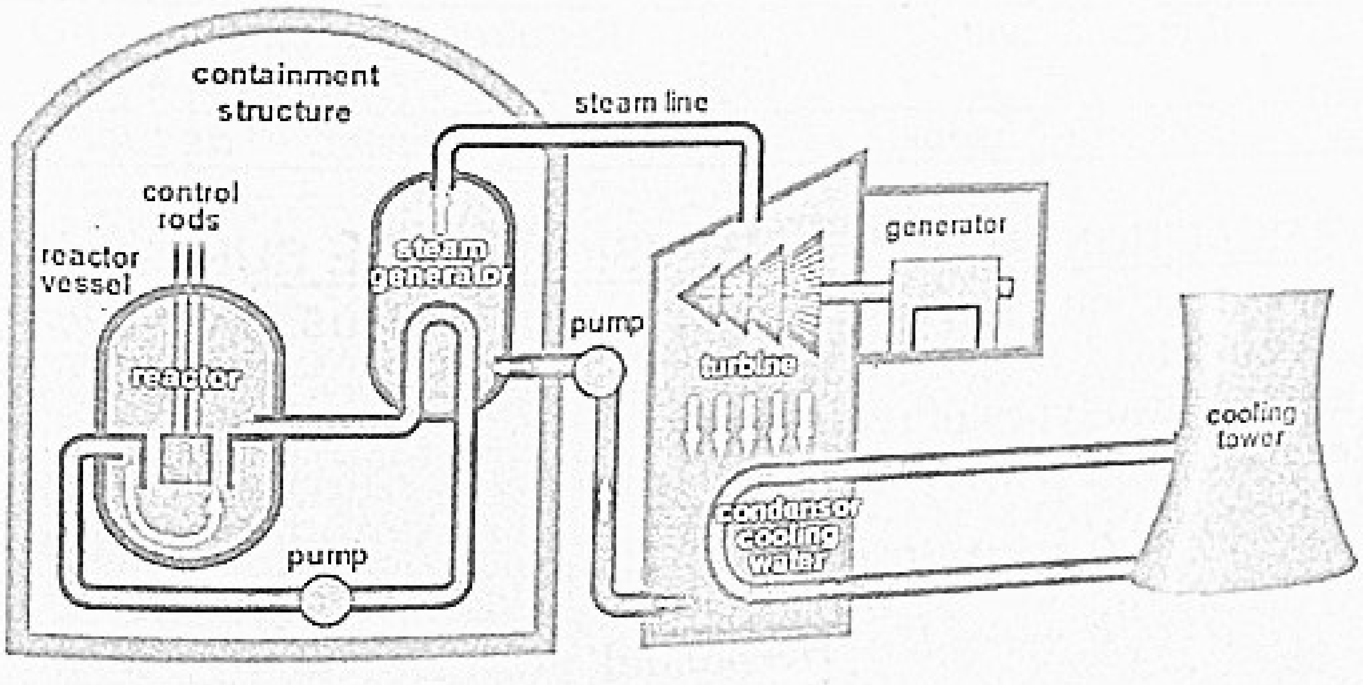
Thus $5 x 10^{26}$ MeV energy is liberated in 0.6μs when 1 kg of $_{92}U^{235}$ undergoes complete fission.

- Plutonium-239 and uranium-233 are also being used as fuel.

NUCLEAR REACTOR

*Fission chain reaction can be controlled in a device called **nuclear reactor**.*

- Nuclear reactor works according to principle that the environment of nuclear reactor is controlled in such a way that only one slow neutron takes part in fission process at a time.



PARTS OF NUCLEAR REACTOR

1- Fuel rods: $_{92}U^{235}$ is used as fuel. In this fuel the quantity of $^{235}_{92}U$ is increased from 2 to 4 percent.

2- Control rods: Ba or Cd rods absorb neutrons efficiently.

3- Moderator: to slow down neutrons usually **graphite**

4- Heat exchanger: to convey the energy produced for the sake of use.

5- Cooling system: to avoid over **heating**

6- Core: consists of fuel, control rods and moderator.

7- Biological shield: to prevent scattering of **harmful radiations.**

8- Breeding: Breeder nuclear reactor is that which prepare its fuel by itself.

TYPES OF NUCLEAR REACTORS

(1) Thermal reactor
(2) Fast reactors

Thermal Reactor

- Neutrons must be **slowed down** to thermal energies to produce fission.
- In this reactor U^{235} is used as fuel.

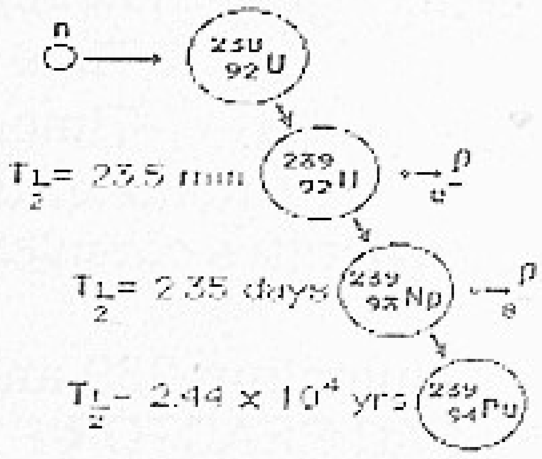
Fast Reactors

- Fast neutrons are used to strike ${}_{92}U^{238}$ producing ${}_{93}Np^{239}$ and then ${}_{94}Pu^{239}$. This type of reactor is liquid metal fast breeder reactor (**LMFBR**)

LIQUID METAL FAST BREEDER REACTOR

- LMFBR produces plutonium according to following scheme:

$${}_0n^1 + {}_{92}U^{238} \text{ (fast)} \rightarrow {}_{92}U^{239} \text{ (unstable)}$$
$(T_{1/2} = 23.5 \text{ minutes})$
$${}_{93}Np^{239} + {}_{-1}\beta^{\circ}$$
$(T_{1/2} = 2.4 \text{ days})$
$${}_{94}Pu^{239} + {}_{-1}\beta^{\circ}$$
$(T_{1/2} = 24400 \text{ years})$



DIFFERENCES BETWEEN THERMAL REACTOR AND LMFBR

Conventional Reactor	*LMFBR*
Moderator	*No moderator*
Coolant is ordinary water or gas	*Na is coolant*
Run continuously	*Requires maintenance after 15 days*
Uses ${}_{92}U^{235}$ as fuel	*Uses ${}_{92}U^{238}$ as fuel*

NUCLEAR REACTIONS & NUCLEAR FUSION IN THE SUN

- Fusion reaction is production of heavy nucleus by nuclear reaction of light nuclei
- There are two types of reactions

i) D-D Reaction

$${}_1^2H + {}_1^2H \longrightarrow {}_2^4He + 24MeV$$

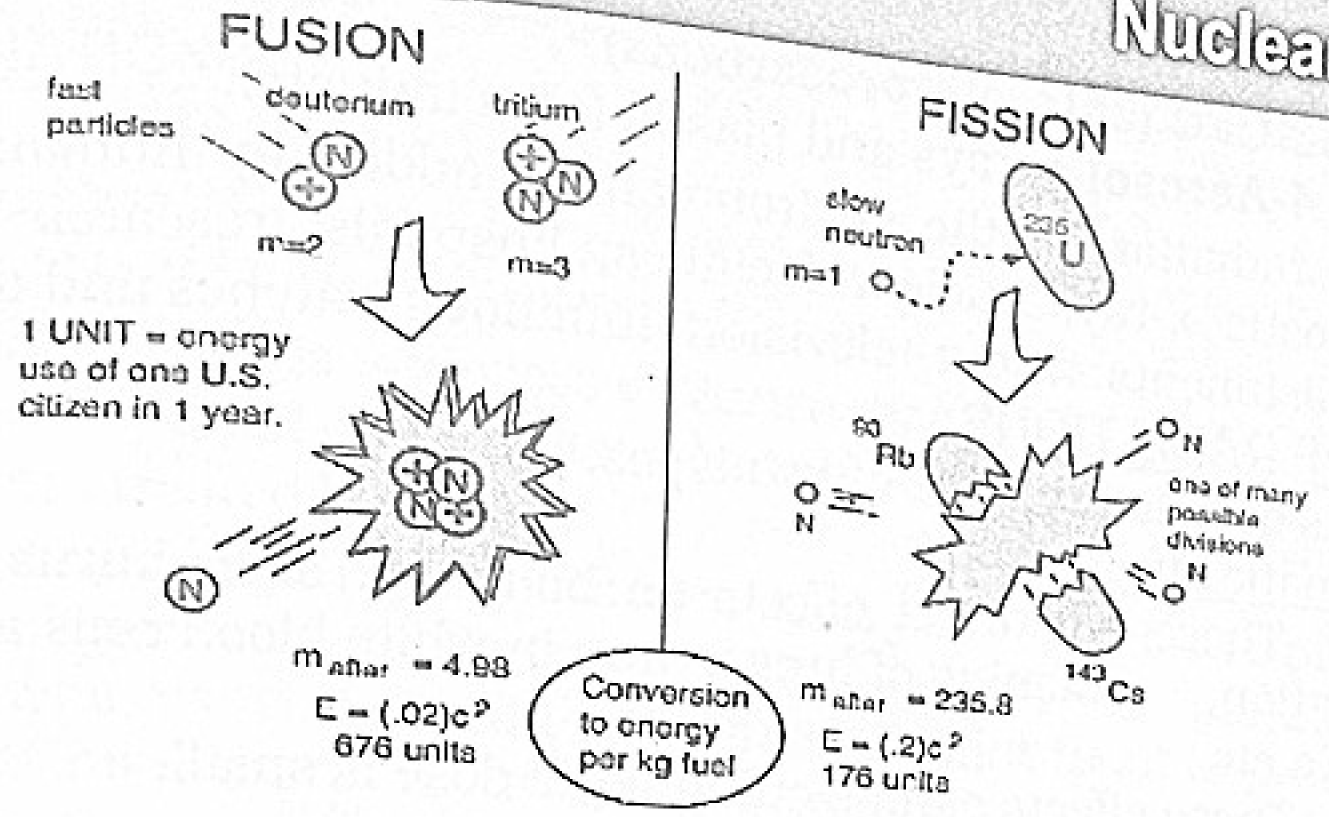
$${}_1^2H + {}_1^2H \longrightarrow {}_1^3H + {}_1^1H + 4.0MeV$$

$${}_1^2H + {}_1^2H \longrightarrow {}_2^3He + {}_0^1n + 3.3MeV$$

ii) D-T Reactions

$${}_1^2H + {}_1^3H \longrightarrow {}_2^4He + {}_0^1n + 17.6MeV$$

- Fusion is more energetic than fission.



Nuclear Reaciton in the Sun

The source of energy in the sun is nucleolus fusion

- The temperature of its core is about 20 million degrees Celsius and its surface temperature is about 6000 degrees Celsius. Its energy is due to fusion reaction called p-p reaction.

  Proton-Proton cycle

  $${}_1H^1 + {}_1H^1 \rightarrow {}_1H^2 + \beta^+ + \upsilon$$
  $${}_1H^2 + {}_1H^1 \rightarrow {}_2He^3 + \gamma$$
  $${}_2He^3 + {}_1He^1 \rightarrow {}_2He^4 + \beta^+ + \upsilon$$

- Stars like sun maintains their shape and pressure due to radiation pressure.

COMPARISON OF ISOTOPES, ISOBARS & ISOTONES

	Isotopes	*Isobars*	*Isotones*
Atomic Number	*Same*	*Different*	*May or may not be the same*
Mass Number	*Different*	*Same*	*May or may not be the same*
No. of Neutrons	*Different*	*May or may not be the same*	*Always same*

RADIATION EXPOSURE

- Radiations can damage **living tissues**. The degree of damage and kind of damage depend on type, energy and dose of radiation. Incident radiations ionize the body cell, and then change biochemistry of the cell. A damaged cell **may die** or **begins to work in wrong way** e.g. sometimes radiation changes the chemistry of cells in such a way hat they begin to reproduce rapidly leading to a **condition called cancer.**
- Damage to ozone layer is done through following sources: -

  1-**Chemical** industry
  2-**Nuclear** tests

3-**CFC (chlorofluorocarbons)**

4-**Aerosol** sprays and plastic foam industry

- Some radiation in the environment is added by human activates like diagnostic x-ray, nuclear facilities, hospitals, research and industrial establishments, colour television, luminous watches and tobacco leaves.

EFFECTS OF RADIATIONS

Effects of radiations are of two types:

1-Somatic effect:

These are direct effects on body e.g. **skin burns, loss of hair,** ulceration, stiffening of lungs, drop in white blood cells and contraction in eyes etc.

These effects can be cured if the dose is small.

2-Genetic effects:

These affect (alter) the chemistry of genes and cause mutation e.g. **cancer, different syndromes etc.**

These effects are incurable and pass on to future generation.

3- Biological Effects

ABSORBED DOSE

Absorbed dose D defined as the energy E absorbed from ionizing radiation per unit mass m of the absorbing body.

$$D = \frac{E}{m}$$

Its SI unit is gray (Gy) .

$$1\text{Gy} = 1\text{Jkg}^{-1}$$

An old unit is rad, an acronym for radiation absorbed dose.

$$1 \text{ rad} = 0.01\text{Gy}$$

Equal doses of different radiations do not produce same biological effect. The effect also depends on the part of the body absorbing the radiation.

- For the same absorbed dose, α -particles are 20 times more damaging than X-rays
- Neutrons are particularly more damaging to eyes than other parts of the body.

EQUIVALENT DOSE

It is defined as the product of absorbed dose and RBE (relative biological effectiveness)

$$1 \text{ Sv} = 1 \text{ Gy} \times \text{RBE} \quad \text{(SI Unit)}$$

Old Unit

$$1 \text{ rem} = 0.01 \text{ Sv}$$

UNIT OF RADIOACTIVITY

- Becquerel (Bq)
  1 Bq = one disintegration per second
- Curie (Ci)
  1 Ci = 3.7×10^{10} Bq

USES OF RADIATIONS

- C-14 is one of useful tracer that can help in the understanding of **photosynthesis.**
- I-131 and Na-24 are used to check **cracks in pipes.**
- Radiation therapy is a process of destruction of cancerous cells deep into body e.g. Co-60 & I-131 are **used to treat cancers.**
- Tumors are treated by **γ-rays.**
- Radio processes in space give information about **structure of stars.**
- When ethylene is radiated with γ-rays, it is polymerized into polyethylene, which is used to **produce soft and flexible products.**
- **Sterilization** is a process of killing of germs with β-particles or γ-rays.
- Radiation treatment can **preserve food** and other eatables.
- γ-gauges are used for preparing or measuring the thickness of high density and thicker materials such as **steel, Al & rubber.** In such gauges, Co-60 is used as γ-rays source.
- β-gauges are used for preparing or measuring the thickness of thin sheets of low density materials e.g. paper. In **such gauges, Sr - 90** is **used as a β-rays source**
- **Radiography** is employed to check cracks of cavities in metal casting, faults in welding & heavy machinery.
- Ratio of C-14 to C-12 found in dead matter is a measure of time span **since death.**
- β particle is used for **superficial skin therapy.**
- α particle is used for deep **skin therapy.**
- Activation analysis (γ-ray energy measurement) is applied to determine concentration of elements in a given sample and to estimate corrosion and wear of machinery.
- Technetium - 99 has given rise to positron emission tomography.
- The ratio of $_{62}Pb^{206}$ — $_{92}U^{238}$ is used to determine age of rocks.

INTERESTING CONSIDERATIONS

- The age of **pyramids** is 4500 years.
- By Ar-40, we can measure dates as back as one million years ago.
- Amino acids have been discovered on **meteorites.**
- To destroy a tumor, we place small pellets of radionuclide near it e.g. radon seed (radon in miniature gold capsule). After destruction of tumor, we remove them.
- Different radioisotopes accumulate in specific parts of body e.g.

Radioisotopes	*Site of Accumulation*
Iodine	*Thyroid gland*
Cobalt	*Liver*
Phosphorus & Calcium	*Bones*

RADIOGRAPHY

- γ-rays radiographs are used in **medical diagnosis**

- Cracks and cavities in castings or pipes are detected by γ ray scanning.
- The gamma camera is used to detect γ radiations from sites in the body where a γ -emitting isotope is located.

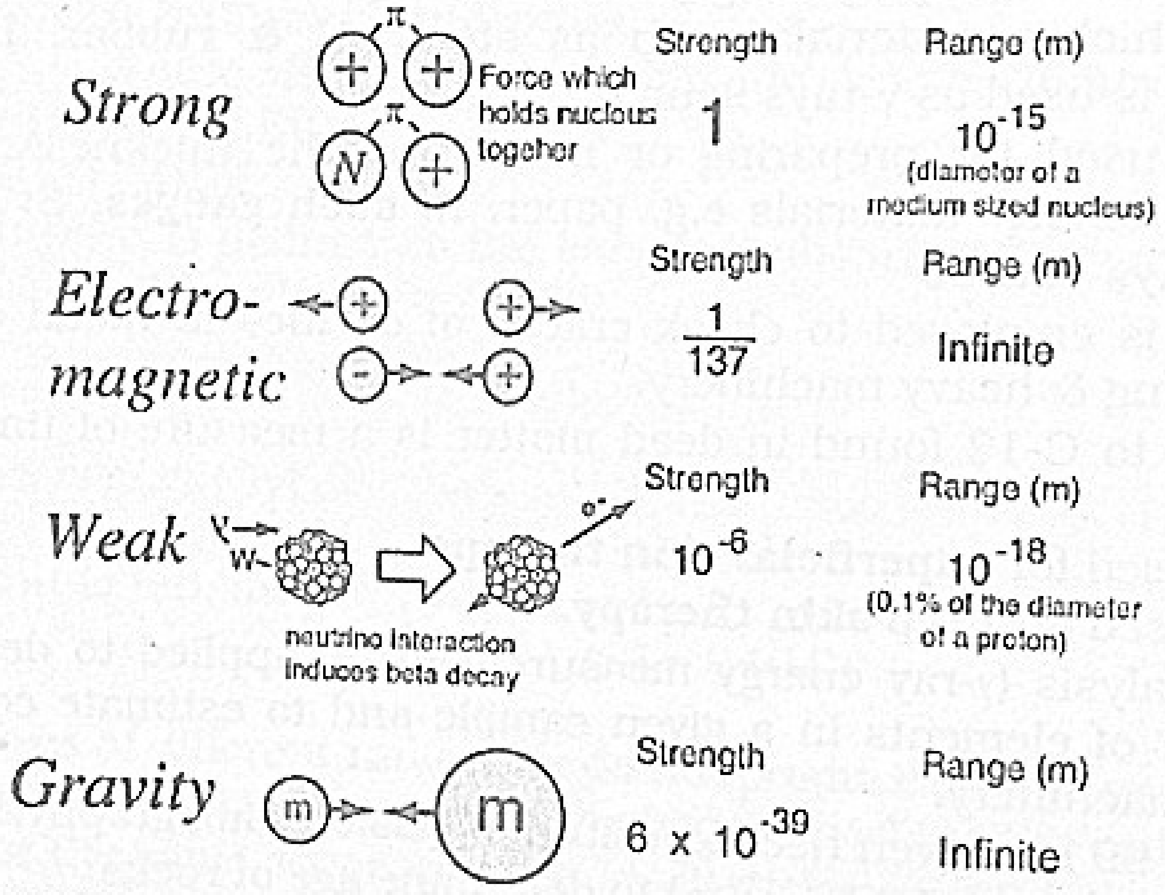
BASIC FORCES OF NATURE

There are now four basic forces in nature.

(1)Gravitational force (long range)
(2) Electromagnetic force (long range)
(3) Strong nuclear force **(short range, 10^{-15}m) attractive**
(4) Weak nuclear force **(short range, 10^{-17}m) repulsive**

In 1979, the physics nobel prize was conferred on Glashow, Weinberg and Abdus Salam for the unification of electromagnetic and weak forces.

Fundamental Forces



BUILDING BLOCKS OF MATTER

Subatomic particles are divided into three groups

(1) Photons
(2) Leptons (electron, muons and neutrinos)
(3) Hadrons

There are two types of hadrons

i- Baryons (the particles equal in mass or greater than protons are called baryons e.g. protons and neutrons)
ii- Mesons (the particles lighter than proton e.g. π mesons)

A pair of quark and antiquark makes a meson and 3 quarks make baryon.

- *Elementary particles are the basic* ***building blocks.***
- All photons and Leptons are elementary particles.
- Hadrons are not elementary particles.
- Hadrons are composed of elementary particles called *quarks.*
- *Matter belongs to either lepton group or quark groups.*

PRACTICE EXERCISE

50 min Time Yourself

(1) The average binding energy of a nucleon inside an atomic nucleus is
(a)1.22MeV (b)8eV
(c)8MeV (d)931MeV

(2) Curie is the unit of
(a)half life (b) intensity
(d)none of these

(3) The radioactive element has the half life of 1600 years, after 6400 years what amount will remain
(a)1/16 (b)1/8
(c)1/2 (d)1/4

(4) The binding energy per nucleon is maximum for
(a)$_{26}Fe^{56}$ (b)$_{92}U^{235}$
(c)$_{56}Ba^{141}$ (d)$_{2}He^{4}$

(5) In typical nuclear fusion the energy released is approx:
(a)8MeV (b)931MeV
(c)200Mev (d)931eV

(6) Which of the following undergo fission reaction easily by slow moving neutrons
(a)U-235 , P-239 (b)P-239 , Th-234
(c)U-238 , Rn-232 (d)Th-234 , U-238

(7) Neutron and proton are commonly known as ________
(a)nucleon (b)meson
(c)boson (d)quartz

(8) Half life of radium is 1590 years. In how many years shall the earth loss all its radium due to radioactive decay?
(a)1590x10^6 years (b)1590x10^{12} years
(c)1590x10^{24} years (d)never

(9) Which one of the following radiation possesses maximum penetrating power?
(a)α-rays (b)β-rays
(c)γ-rays (d)all have equal penetrating power

(10) Electrons________
(a)can exist inside the nucleus
(b)cannot exist inside the nucleus
(c)can exist both inside and outside the nucleus
(d)don't know

(11) Radioactivity is a ________
(A) Spontaneous activity
(B) Chemical property
(C) Self disintegration property
(D) Which of above statements is/are correct?
(a)A&B (b)B&C
(c)C&A (d)A,B&C

(12) Energy liberated when one atom of U-235 undergoes fission reaction is __

(a)200MeV (b)40MeV

(c)30MeV (d)20MeV

(13) Transuranic elements have atomic number ____________

(a)greater than 72 (b)greater than 82

(c)greater than 92 (d)greater than 102

(14) Nuclear forces exist between ____________

(a)proton-proton (b)proton-neutron

(c)neutron-neutron (d)all of the above

(15) Mass defect per nucleon is __________

(a)binding energy of nucleus (b)packing fraction

(c)average energy of nucleus (d)all of above are one and same thing

(16) Tick the correct statement

(a)moderators slow down the neutrons

(b)moderators bring the neutrons to rest

(c)moderators absorb the neutrons

(d)moderators reflect the neutrons

(17) The bombardment of nitrogen with α-particles will produce ____________

(a)neutron (b)proton

(c)electron (d)positron

(18) Diameter of an atom is approximately___________

(a)10^{-12}m (b)10^{-11}m

(c)10^{-10}m (d)10^{-14}m

(19) Which of the following isotopes is normally fissionable?

(a) ${}^{238}_{92}U$ (b) ${}^{239}_{93}Np$

(c) ${}^{235}_{92}U$ (d) ${}^{4}_{2}He$

(20) Average energy required to remove one nucleon from the nucleus is called _____

(a)binding energy per nucleon (b)energy of decay

(c)destruction energy (d)all of above

(21) Fission chain reaction in a nuclear reactor can be controlled by introducing ________

(a)iron rods (b)graphite rods

(c)cadmium rods (d)platinum rods

(22) Which one of the following radiations possesses maximum velocity?

(a)α-rays (b)β-rays

(c)γ-rays (d)all of above have same speed

(23) Charge on an electron was determine by __________

(a)Ampere (b)Maxwell

(c)Millikan (d)Thomson

(24) Charge on neutron is ___________

(a)+ 1.6×10^{-19} C (b)zero

(c)-1.6×10^{-19} C (d)no definite charge

(25) A particle having the mass of an electron and the charge of a proton is called a__________

(a)antiproton (b)positron

(c)gamma rays (d)photon

(26) Mass of neutron is ________

(a) 1.67×10^{-31} kg (b) 1.67×10^{-27} kg

(c) 9.1×10^{-31} kg (d) 1.67×10^{-19} kg

(27) Nuclei having the same mass number but different atomic number are__

(a) Isotopes (b) Isobars

(c) Isotones (d) Isomers

(28) A mass spectrograph (spectrometer) sorts out ________

(a) molecules (b) atoms

(c) elements (d) isotopes

(29) Sum of the masses of constituent nucleons as compared to the mass of the resultant nucleus is ________

(a) smaller

(b) greater

(c) same

(d) some times smaller some times greater

(30) An α-particle is emitted from $_{88}Ra^{226}$. What is the mass and atomic number of the daughter nucleus?

	Mass number	atomic number
(a)	224	86
(b)	220	80
(c)	222	86
(d)	226	87

(31) The unit of radioactivity 'curie' is equal to ________

(a) 3.74×10^{9} disintegration per sec

(b) 3.70×10^{10} disintegration per sec

(c) 3.55×10^{10} disintegration per sec

(d) 3.60×10^{10} disintegration per sec

(32) A radioactive samplewith half life of 1month has activity $2\mu Ci$. Its activity 2 months earlier was

(a) $1\mu Ci$ (b) $0.5\mu Ci$

(c) $4\mu Ci$ (d) $8\mu Ci$

(33) In liquid metal fast breeder reactor, the type of uranium used is ____

(a) $_{92}U^{235}$ (b) $_{92}U^{238}$

(c) $_{92}U^{234}$ (d) $_{92}U^{239}$

(34) Radioactive materials can be identified by measuring their ________

(a) hardness (b) mass

(c) half life (d) total life

(35) If one or more of the neutrons emitted during fission can be used to build up further fission then the reaction is self sustained and is known as __

(a) fission reaction (b) fusion reaction

(c) chain reaction (d) chemical reaction

(36) Pair production takes place in the vicinity of a heavy nucleus so that __

(a) net energy is conserved (b) net charge is conserved

(c) net momentum is conserved (d) all of the above

(37) During an encounter with an atom, α-particle knocks out________

(a) protons (b) electrons

(c) neutrons (d) nothing

(38) The path of β-particle is ____________
(a)rectilinear (b)curved
(c)zig-zag or erratic (d)elliptical

(39) Which of the following radiations are suitable for the treatment of an infection in the interior of the body?
(a)α-rays (b)β-rays
(c)γ-rays (d)X-rays

(40) Various types of cancer are treated by ____________
(a)cobalt-60 (b)strontium-90
(c)carbon-14 (d)nickel-63

(41) Sterilization of surgical instruments, medical supplies and bandages can be done by exposing them to a beam of ____________
(a)α-rays
(b)β-rays
(c)γ-rays
(d)'b' and 'c' have equal antiseptic properties

(42) Charge on α-particles is ____________
(a)+1 (b)+2
(c)–2 (d)-1

(43) β-particle ionizes an atom ____________
(a)through direct collision
(b)through electrostatic attraction
(c)through electrostatic repulsion
(d)all of above

(44) T.V sets and microwave ovens emits ____________
(a)X-rays (b)α-rays
(c)β-rays (d)γ-rays

(45) A β-particle in a single encounter ____________
(a)loses a small fraction of its energy
(b)losses most of its energy
(c)loses no energy at all
(d)loses all of its energy

(46) Strontium-90 is used as ____________
(a)β-particle source (b)α-particle source
(c)γ-rays source (d)neutron source

(47) The penetration power of β-particle as compared to α-particle is ____________
(a)10 times more (b)100 times more
(c)100 times less (d)10 times less

(48) Geiger counter is suitable for ____________
(a)fast counting (b)extremely fast counting
(c)slow counting (d)all situations

(49) A α-particle can produce fluorescence in ____________
(a)ZnS (b)barium platinocyanide
(c)sodium iodide (d)all of above

(50) Pair production cannot take place in vacuum as ________ is not conserved
(a)energy (b)charge
(c)mass (d)momentum

(51) CFC is used in ____________

(a)refrigeration
(b)aerosol spray
(c)plastic foam industry
(d)all of above

(52) Average distance covered by α-particle in air before its ionizing power ceases, is called its ____________

(a)trajectory
(b)range
(c)firing level
(d)limit

(53) Which one of the following possesses greater penetration power?

(a)α-rays
(b)β-rays
(c)γ-rays
(d)neutron-rays

(54) The most useful tracer is ____________

(a)Sr-90
(b)I-131
(c)Ca-41
(d)C-14

(55) γ-rays are electromagnetic waves like ____________

(a)light waves
(b)heat waves
(c)micro waves
(d)x-rays

(56) Charge on β-particle is ____________

(a)±1
(b)–1
(c)+2
(d)–2

(57) Why γ-rays are used to kill bacteria, to sterilize surgical equipments etc?

(a)chargeless
(b)massless
(c)highly penetrating
(d)all of above

(58) β-particle ionizes an atom ________

(a)due to electrostatic force of attraction
(b)due to electrostatic force of repulsion
(c)due to direct collision
(d)due to gravitational force

(59) β-particles possess greater penetration power than that of α particles due to its ________

(a)smaller ionization power
(b)greater ionization power
(c)neither greater nor smaller ionization power
(d)same ionization power

(60) Enriched uranium is better as a fuel for a nuclear reactor because it has greater proportion of

(a) ^{233}U
(b) ^{235}U
(c) ^{238}U
(d) ^{239}U

(61) Pair production can take place only with ____________

(a)X- rays
(b) γ -rays
(c)UV-rays
(d)IR-rays

(62) A device for producing high velocity nuclei is ____________

(a)cloud chamber
(b)linear accelerator
(c)a mass spectrograph
(d)Wilson cloud chamber

(63) Which of the following will be a better shield against γ -rays?

(a)ordinary water
(b)heavy water
(c)lead
(d)aluminum

(64) The maximum safe limit dose for persons working in nuclear power station are ________

(a)1 rem per week
(b)5 rem per week
(c)4 rem per week
(d)3 rem per week

(65) Radiations are used for the treatment of skin of a patient is ________

(a)α-rays
(b)β-rays
(c)γ-rays
(d)X-rays

SCIENTISTS

Name	Field of Contributions
Ancient Babylonians and Egyptians	Fundamentals of physics
Chinese	Magnetic compass
Thales	Static electricity
Pythagoras	Pythagorean theorem
Democritus	Atomic nature of matter
Aristotle	First book on physics
Euclid	Geometrical optics
Archimedes	Founder of mathematical physics (Optics, mechanics, hydrostatics & hydraulics)
Al-Beruni	Circumference of the earth and Latitudes and longitudes
Ibn-Jabir	Tables of sun eclipses year wise and trigonometric ratios
Arabs	Methods for solution of 3rd and 4th degree equations
Al-Khawrizmi	Books on Algebra, Astronomy and Arithmetic
Jabir Bin Hayyan	Preparation of nitric acid and phosphoric acid and calcinations and reduction
Inb-al-Haitham	Optics
Omer Khayyam	Calendar
Kepler	Kepler's law ($R^2 \alpha T^3$)
Galileo	Fundamental ideas of modern celestial mechanics such as simple pendulum
Newton	1- Three laws of motion. 2- Law of gravitation. 3- Nature of light. 4- Propagation of light. 5- Calculus. 6- Newton's law of cooling.
Bernoulli	Hydrodynamics and gas theory
D. Alembert	Theoretical Mech. And gas theory
Fahrenheit	Thermometer and temperature scales.
Black	Latent heat and specific heats

SCIENTISTS

Rumford	Mechanical theory of heat
Rowland	Heat theory
Kelvin	Laws of thermodynamics and Kelvin's temperature scale.
Michelson	Interferometer, speed of light.
Huygen	Wave theory and Huygen's principle.
Fresnel	Interferences and polarization
Malus and Brewster	Polarization of light
Maxwell	e.m. wave theory and Maxwell's equation
Crookes	Cathode rays.
J.J Thomson	Discovery of electron
Lorentz	Electron theory of mater.
Roentgen	Discovery of x-rays
Becquerel	Discovery of radioactivity
Plank	Quantum theory
Einstein	Theory of relativity
Rutherford	Nuclear physics and atomic model
Bohr	Atomic model
De-Broglie	Wave mechanics
Heisenberg	Uncertainly principle
Dirac and Shrodinger	Advanced quantum mechanics
Davison, Germer & G.P Thomson	Verification of De-Broglie's postulates
Chadwick	Discovery of neutron
Lawrence	Cyclotron
Curie (family)	Artificial radioactivity
Fermi	Atom bomb
Hahn	Fission inventor
Bardeen	Transistor
Muller and Bednorz	Super conductivity
Muller and Bednorz	Super conductivity
Dr.A.Salam	Unification of weak force and e.m. force

SAMPLE PAPER BY KIPS

45 mins
Time Yourself

MCAT/ECAT

Note:- physics paper of ECAT contains 30 questions while MCAT contains 60 questions, so extra questions have been added in the sample paper.

(1) In a tug of war between group A and group B, B is winning. Who is doing work
(a) group A (b) group B
(c) both group A and B (d) neither group A nor B

(2) The closed tank in which Biogas is produced by rotting of biomass named as
(a) digester (b) container
(c) biogaster (d) gas plant

(3) When a body has decreasing angular velocity then the direction of angular velocity is same that of
(a) angular acceleration (b) angular momentum
(c) both a and b are correct (d) neither a nor b is correct

(4) If earth shrinks to half the present radius the duration of day and night will be
(a) 24 hours (b) 12 hours
(c) 6 hours (d) 3 hours

(5) The spokes used in a cycle wheel increases its
(a) momentum of inertia (b) centripetal acceleration
(c) tangential acceleration (d) radial acceleration

(6) Light roofs are blown of during wind storm. It is because of
(a) less weight of roof (b) more height of roof
(c) difference in pressure (d) all are correct

(7) The flow in which every particle passing a given point follows the same path and speed is called
(a) turbulent flow (b) streamlined flow
(c) zig zag flow (d) none of these

(8) For which position will the maximum blood pressure in the body have the smallest value
(a) standing upright (b) sitting on chair
(c) standing on one leg (d) lying horizontally

(9) The maximum velocity of SHM is a_0 the period of oscillation is
(a) $2\pi x_0/a_0$ (b) $2\pi a_0/x_0$
(c) $2\pi a_0 x_0$ (d) $2\pi/a_0 x_0$

(10) The time period of mass spring system can increased by
(a) increasing spring constant of spring
(b) increasing weight of body attached
(c) increasing amplitude of vibration
(d) decreasing amplitude of vibration

(11) In stretched string the frequency of vibration is given by $f=1/2L\sqrt{F/m}$. In this equation m has dimension

(a) M
(b) ML
(c) ML^{-1}
(d) ML^{-2}

(12) In wave motion the least distance between two points which are out of phase is

(a) λ
(b) $\lambda/2$
(c) $3\lambda/2$
(d) $\lambda/4$

(13) A particle performing SHM when its displacement is 3 cm, its acceleration is 12 cm S^{-2}- . It is vibrating with period

(a) 4π Sec
(b) 2π Sec
(c) π Sec
(d) 4π Sec

(14) As a result of interference, energy

(a) is lost
(b) is gained
(c) is transmitted and reflected
(d) remained unchanged as a whole but is redistributed

(15) When white light is used in Double Slit experiment then

(a) non interference fringes observed
(b) only red and white fringes are observed
(c) only central bright fringe is observed
(d) central bright and few coloured fringes are observed

(16) Michelson determined velocity of light by

(a) using a rotating plane mirror
(b) using an octagonal rotating mirror
(c) studing rotation of moon and sun
(d) using interferometer

(17) In case of spectrometer circular scale, graduated in half degree, is attached with

(a) collimator
(b) telescope
(c) turn table
(d) cross wire of telescope

(18) The value of γ for polyatomic gas is

(a) 1.4
(b) 1.67
(c) 1.29
(d) 1.42

(19) During a reversible cycle the entropy of the system

(a) become zero
(b) become infinite
(c) increases
(d) does not change

(20) A satellite moving round the earth constituents

(a) inertial frame
(b) non inertial frame
(c) neither inertial nor non inertial frame
(d) both inertial and non inertial frame

(21) Resonant frequency of a RLC series circuit is mainly determined by

(a) resistance
(b) inductance L
(c) capacitance C
(d) both inductance L and capacitance C

(22) The resistance R of a series RLC circuit is mainly responsible for
(a) determining the resonance frequency
(b) limiting circuit current
(c) fixing the power factor
(d) all are correct

(23) What is the power of a convex lens of focal length.
(a) 10 diopter (b) 1 diopter
(c) 0.1 diopter (d) 100 diopter

(24) Neutral P type semi conductor has
(a) no free electrons (b) no hole
(c) neither free nor holes (d) both free electrons and holes

(25) The width of the deletion region of a junction is reduced under forward bias because
(a) more charge carriers are available
(b) number of minority charge carriers are reduced
(c) majority carriers on both sides of junction are driven towards it
(d) doping level is increased

(26) In case of full wave rectifier the rectified D.C has a.c ripples. The ripple frequency is
(a) same that of input A.C
(b) twice than frequency of input A.C
(c) half than frequency of input A.C
(d) four times the frequency of input A.C

(27) A PNP transistor has
(a) only donor ions (b) only acceptor ions
(c) two p region and one n region (d) three pn junction.

(28) In a two input logic gate both inputs are at O and the output is 1 the gate would be
(a) NAND (b) NOR
(c) XNOR (d) any of given gates in a, b and c

(29) If stress produce change only in the length of the solid then it is called as
(a) tensile stress (b) volume stress
(c) shear stress (d) none

(30) Einstein was awarded Nobel Prize for his work on
(a) theory of relativity (b) nuclear fission
(c) photoelectric effect (d) all are correct

(31) The final image produced by electron microscope can be seen
(a) on florescent screen (b) on electron micrograph
(c) scanning micrometer (d) only a and b are current

(32) The energy of electron in 10th orbit of Hydrogen atom is
(a) 1.36 ev (b) −0.136 ev
(c) 0.136 ev (d) −0.136 ev

(33) The frequency of the emitted X-rays from a target depends upon
(a) nature of target material (b) accelerating voltage for electron
(c) both are correct (d) temperature of target

(34) The ratio of period of excitation in ordinary and mata stable state is

(a) $1:10^5$ (b) $10^5:1$

(c) $1:10^8$ (d) $1:10^{-8}$

(35) The atomic number and mass number of a nucleus is Z and A. there new value after emission of two alpha and two beta radiation is

(a) Z-2,A-4 (b) Z-2,A-8

(c) Z-4,A-4 (d) Z-4,A-8

(36) The particle which are lighter than protons are called

(a) photons (b) mesons

(c) hadrons (d) baryons

(37) If there is one disintegration per second in radioactive sample then its activity is

(a) Becquerel (b) Curi

(c) rbe (d) gray

(38) What is the particle emitted during the reaction

${}_4^9Be+{}_2^4He\rightarrow{}_6^{12}C+?$

(a) proton (b) neutron

(c) deuterium (d) beta-particle

(39) A radiation leave no definite track in Wilson cloud chamber then it is

(a) alpha (b) beta

(c) gamma (d) any of a, b and c

(40) The galvanometer used in AVO meter differ from ordinary Lab. galvanometer

(a) it is suspended type (b) it has variable coil resistance

(c) its zero is at left extreme (d) it required no current for deflection

(41) A cube with sides 2cm long is made from a material of density 8gcm-3. Its mass is

(a) 4g (b) 16 g

(c) 32g (d) 64g

(42) Prefix giga stands for

(a) 10^6 (b) 10^9

(c) 10^{-6} (d) 10^{-9}

(43) Which pair not has same dimension

(a) pressure, stress (b) spring constant, surface tension

(c) angular velocity, time period (d) momentum, impulse

(44) Which one is not a correct equation

(a) $A^\wedge=A/A$ (b) $A=A.A^\wedge$

(c) $A=A\,.\,A^\wedge$ (d) $A = A \times A^\wedge$

(45) What will be the angle between A and B, if A+B = B+A

(a) 0^0 (b) 60^0

(c) 90^0 (d) any value

(46) For complete equilibrium body must have

(a) zero linear acceleration

(b) zero angular acceleration

(c) both linear and angular acceleration zero

(d) zero torque

(47) Which of the following changes when a particle is moving with uniform velocity

(a) speed (b) momentum

(c) position vector (d) velocity

(48) Two bodies are moving in two mutually perpendicular directions with speed V. The magnitude of their relative velocities is
(a) $\sqrt{2}V$
(b) $2\sqrt{V}$
(c) $V/\sqrt{2}$
(d) 2V

(49) If R is the range of projectile then its K.E be maximum after covering a horizontal distance
(a) R/4
(b) R/2
(c) 3R/4
(d) R

(50) On microscopic scale, all forms of energies may be classified as
(a) K.E
(b) P.E
(c) K.E or P.E
(d) nuclear energy

(51) An alpha particle moves through potential difference 1 volt it may gain K.E equal to
(a) 1 ev
(b) 2 ev
(c) 3 ev
(d) 4 ev

(52) When charges become twice and their separation also become twice then coulomb's force between them
(a) remains same
(b) become half
(c) become double
(d) become eight time

(53) On selenium surface of drum the image of the document is produced. It is in the form of
(a) neutral portions
(b) bright portions
(c) positive charged portions
(d) negative charged portions

(54) The drift velocity of the free electrons in conductors is of the order of
(a) $10^{-3}ms^{-1}$
(b) $10^{-3}Kms^{-1}$
(c) $10^{-3}cms^{-1}$
(d) $10^{-3}mms^{-1}$

(55) With rise in temperature the resistance of semiconductor.
(a) increases
(b) decreases
(c) remains same
(d) becomes infinite

(56) When two resistances are connected in series they have
(a) same resistance value
(b) same voltage across them
(c) only one current path
(d) different resistance value

(57) While applying Kirchoff's Laws to electronic circuits, the assumed direction of current flow must be
(a) clockwise
(b) anticlockwise
(c) from left to right
(d) either a or b

(58) Magnets made of low retentivity but high permeability iron are called
(a) electromagnets
(b) permanent magnets
(c) weak magnets
(d) one pole magnets

(59) A step up transformer always steps down
(a) power
(b) reactance
(c) current
(d) frequency

(60) The path difference between two identical sinusoidal current waves is $\lambda/6$ their phase difference is
(a) 30^0
(b) 60^0
(c) 180^0
(d) 15^0

ANSWER KEY (PART-II)

CHAPTER-12

1	B	11	B	21	A	31	D	41	A
2	C	12	B	22	A	32	C	42	B
3	A	13	D	23	C	33	A	43	C
4	B	14	A	24	B	34	B	44	B
5	A	15	D	25	B	35	B	45	A
6	C	16	C	26	C	36	C	46	B
7	B	17	A	27	B	37	B	47	D
8	D	18	D	28	B	38	A	48	A
9	B	19	B	29	A	39	A	49	C
10	B	20	A	30	B	40	B	50	B

CHAPTER-13

1	A	11	A	21	B	31	C
2	D	12	C	22	C	32	B
3	A	13	A	23	B	33	A
4	A	14	D	24	A	34	B
5	B	15	C	25	C	35	D
6	B	16	C	26	A	36	C
7	B	17	C	27	A	37	B
8	D	18	A	28	C	38	C
9	A	19	C	29	A	39	D
10	A	20	A	30	D	40	A

CHAPTER-14

1	C	11	B	21	C	31	D
2	C	12	D	22	A	32	A
3	C	13	D	23	B	33	D
4	B	14	A	24	A	34	D
5	B	15	B	25	D	35	C
6	A	16	D	26	A	36	B
7	A	17	D	27	A	37	A
8	D	18	C	28	C	38	A
9	C	19	B	29	D	39	A
10	D	20	C	30	A	40	D

CHAPTER-15

1	D	11	B	21	D	31	A
2	C	12	D	22	D	32	B
3	C	13	C	23	A	33	D
4	B	14	B	24	A	34	B
5	D	15	A	25	C	35	C
6	D	16	A	26	B	36	A
7	A	17	C	27	A	37	B
8	D	18	D	28	C	38	B
9	C	19	B	29	A	39	C
10	D	20	B	30	D	40	A

CHAPTER-16

1	B	11	D	21	B	31	A
2	C	12	B	22	A	32	B
3	B	13	D	23	C	33	D
4	C	14	A	24	B	34	D
5	D	15	B	25	D	35	B
6	A	16	D	26	A	36	A
7	C	17	A	27	B	37	B
8	C	18	B	28	C	38	B
9	B	19	B	29	B	39	C
10	C	20	D	30	D	40	D

CHAPTER-17

1	B	11	C	21	D	31	D
2	A	12	B	22	C	32	B
3	C	13	B	23	B	33	C
4	D	14	A	24	C	34	C
5	B	15	B	25	A	35	C
6	B	16	C	26	B	36	D
7	B	17	D	27	D	37	B
8	D	18	B	28	A	38	B
9	A	19	B	29	D	39	C
10	C	20	C	30	C	40	A

CHAPTER-18

1	B	11	C	21	C	31	A
2	A	12	C	22	A	32	D
3	D	13	A	23	D	33	B
4	C	14	C	24	B	34	B
5	D	15	C	25	D	35	B
6	B	16	A	26	B	36	D
7	C	17	C	27	B	37	A
8	B	18	B	28	B	38	B
9	A	19	A	29	B	39	B
10	A	20	D	30	A	40	A

CHAPTER-19

1	D	11	C	21	C	31	B
2	D	12	B	22	D	32	A
3	D	13	C	23	D	33	C
4	B	14	C	24	C	34	B
5	B	15	B	25	A	35	B
6	D	16	B	26	D	36	D
7	A	17	D	27	B	37	B
8	C	18	C	28	A	38	C
9	B	19	C	29	C	39	A
10	A	20	C	30	D	40	B

CHAPTER-20

1	B	11	C	21	A	31	B
2	A	12	C	22	C	32	A
3	D	13	B	23	B	33	C
4	C	14	C	24	B	34	D
5	B	15	C	25	A	35	B
6	C	16	A	26	D	36	C
7	A	17	A	27	C	37	C
8	A	18	D	28	A	38	A
9	C	19	C	29	B	39	A
10	D	20	A	30	D	40	C

CHAPTER-21

1	C	11	C	21	C	31	B	41	C	51	D	61	B
2	B	12	A	22	C	32	D	42	B	52	B	62	B
3	A	13	C	23	C	33	B	43	C	53	D	63	C
4	A	14	D	24	B	34	C	44	A	54	D	64	B
5	C	15	B	25	B	35	C	45	B	55	D	65	B
6	A	16	A	26	B	36	C	46	A	56	A		
7	A	17	B	27	B	37	B	47	C	57	C		
8	D	18	C	28	D	38	C	48	C	58	B		
9	C	19	C	29	B	39	C	49	D	59	A		
10	B	20	A	30	A	40	A	50	D	60	B		

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1	D	11	C	21	D	31	D	41	D	51	B
2	A	12	B	22	B	32	D	42	B	52	A
3	B	13	C	23	A	33	C	43	C	53	C
4	C	14	D	24	D	34	A	44	D	54	A
5	A	15	D	25	C	35	B	45	D	55	B
6	C	16	B	26	B	36	B	46	C	56	C
7	B	17	C	27	C	37	A	47	C	57	D
8	D	18	C	28	D	38	B	48	A	58	A
9	D	19	D	29	A	39	C	49	D	59	C
10	B	20	B	30	C	40	B	50	B	60	B

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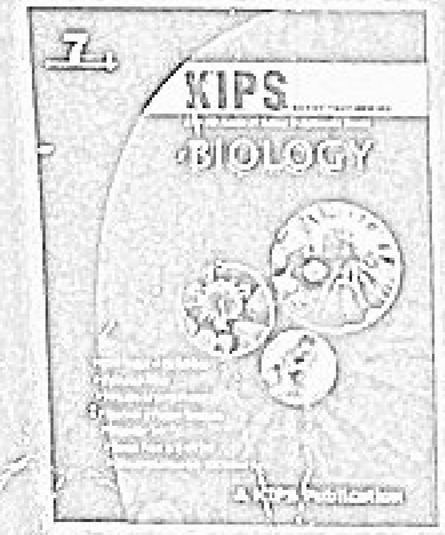

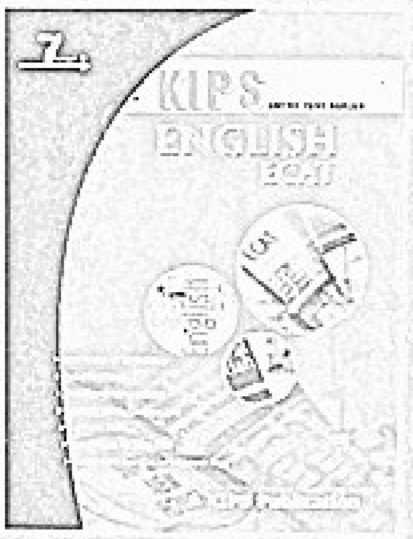

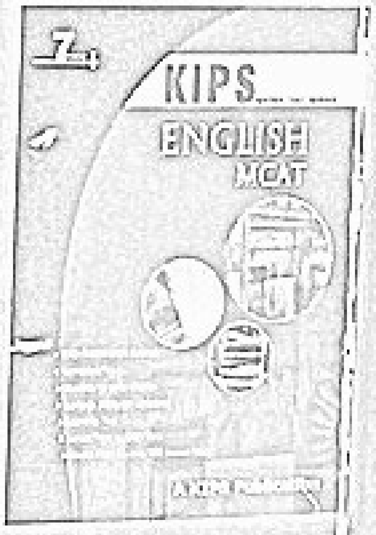

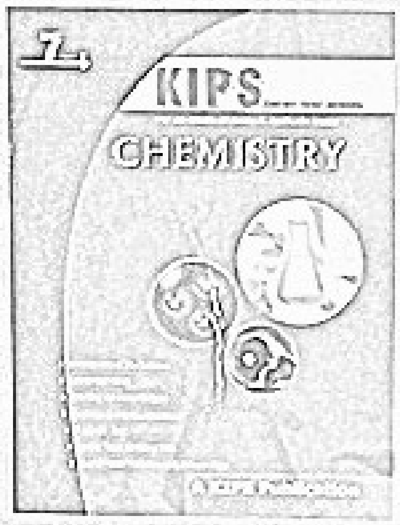

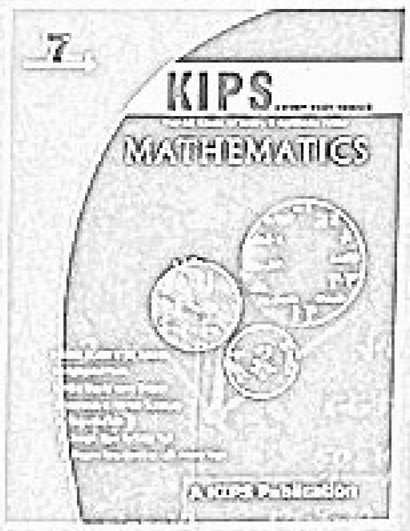

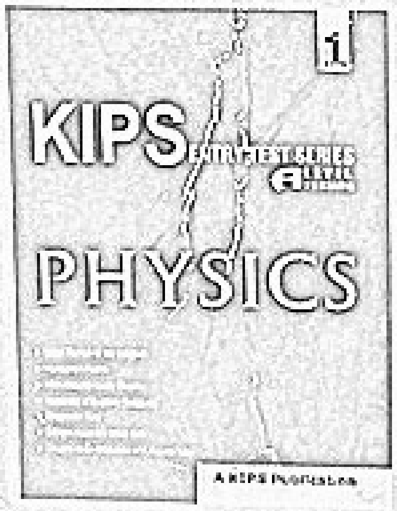

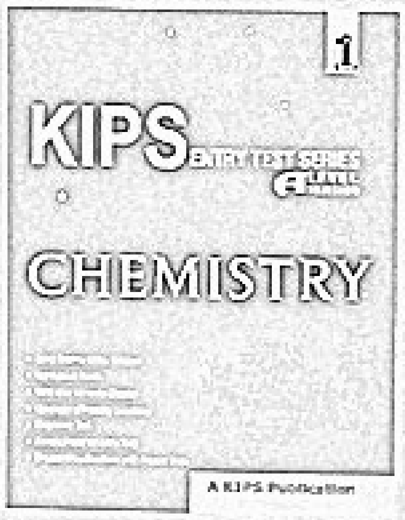

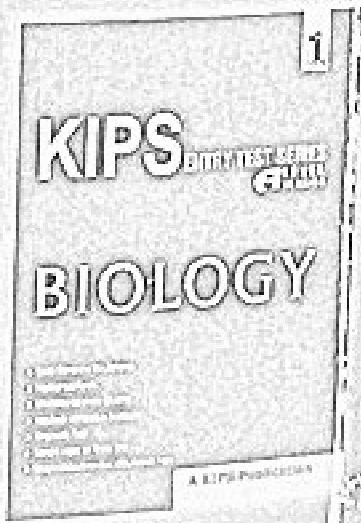

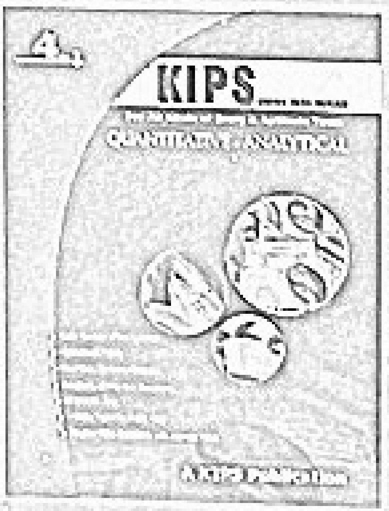

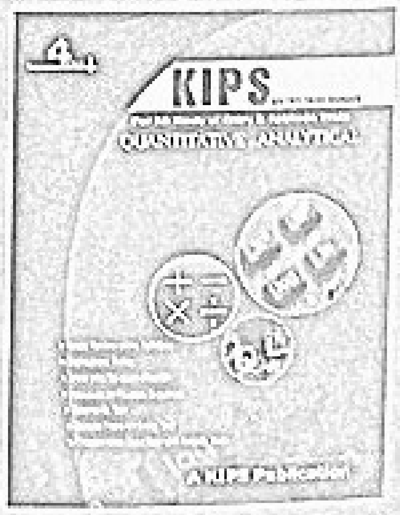

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